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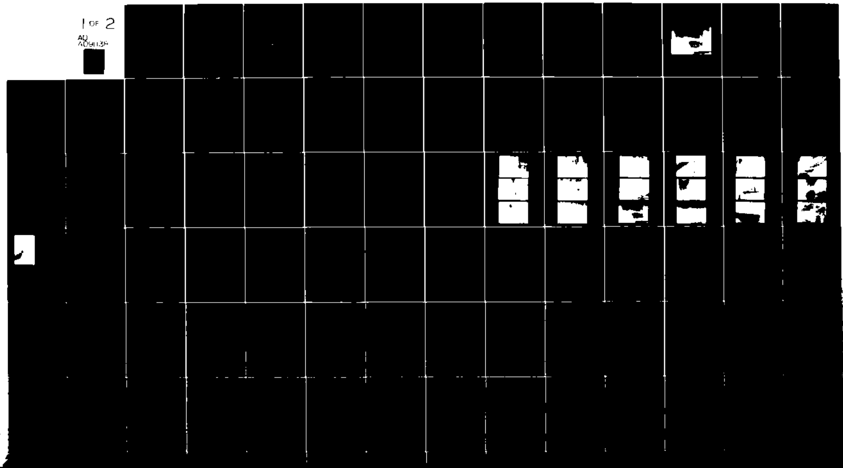

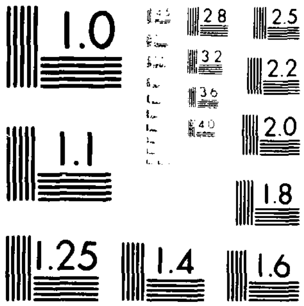
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Chautauqua County
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Canadaway Creek

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides information and analysis on the physical condition of the dam as of the report date. Information and analysis are based on visual inspection of the dam by the performing organization.

Examination of available documents and a visual inspection of the dam revealed conditions which if not corrected constitute a hazard to human life or property.

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Using the Corps of Engineers screening criteria for review of spillway adequacy, it has been determined that the dam would be overtopped by all storms exceeding approximately 34 percent of the PMF. The overtopping of the dam could cause erosion in the notched earthen section adjacent and parallel to the concrete Ogee weir resulting in possible undermining and failure of the spillway. Failure of the spillway would result in an increased hazard to the loss of life and property downstream. The spillway is, therefore, judged as "seriously inadequate" and the dam is assessed as unsafe, non-emergency.

The classification of "unsafe" applied to a dam because of a "seriously inadequate" spillway is not meant to imply the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, there appears to be a serious deficiency in the spillway capacity and if a severe storm were to occur, overtopping and possible failure of the spillway and dam could take place, thereby significantly increasing the hazard to loss of life downstream of the dam.

Structural stability analysis based on available information and the visual inspection indicates that the stability of the spillway section against overturning and sliding is inadequate for nealy all loading conditions other than those when the reservoir is at the spillway crest.

Seepage was detected adjacent to the spillway and in the downstream slope of the west embankment. A wet area was observed along the downstream slope of the east abutment-embankment contact of the east embankment. Those wet areas and seeps could seriously affect the stability of the spillway and embankment.

It is, therefore, recommended that within 3 months of notification to the owner, detailed hydrologic/ hydraulic investigation of the structure should be undertaken to better determine the site specific characteristics of the watershed and their affect upon potential overtopping of the dam. The results of these investigations will determine the appropriate remedial measures which will be required to achieve a spillway capacity adequate to discharge the outflow from at least one-half the PMF. A detailed field investigation and monitoring program should be undertaken to determine the source of seepage and the wet areas noted above. At the same time a detailed investigation should be performed to determine the structural stability of the spillway and slope stability of the downstream embankment slopes.

At this time we do not recommend the trees be removed from the embankment slopes unless provisions are made to drain and protect these slopes using a granular drainage blanket. Indiscriminate cutting of trees could result in serious sloughing of the slopes.

In the interim, a detailed emergency action plan must be developed and implemented providing around-the-clock monitoring of the structure and provisions for notification of downstream residents during periods of unusually heavy precipitation.

LAKE ERIE BASIN

FREDONIA RESERVOIR

CHAUTAUQUA COUNTY, NEW YORK
INVENTORY NO. N.Y. 749

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM.

⑥ Fredonia Reservoir, (Inventory number NY-749), Lake Erie Basin, Chautauqua County, New York. Phase I Inspection Report,

Bent L. Thomsen
Gary L. Wood

Prepared by
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Prepared for
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NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
FREDONIA RESERVOIR
I. D. NO. N.Y. 749
LAKE ERIE BASIN
CHAUTAUQUA COUNTY, NEW YORK

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

NAME OF DAM:	Fredonia Reservoir Inventory No. N.Y. 749
STATE LOCATED:	New York
COUNTY:	Chautauqua
WATERSHED:	Lake Erie
STREAM:	Canadaway Creek
DATE OF INSPECTION:	May 14, 15, and 22, 1930 See Vicinity Map and Topographic Map, Appendix C

ASSESSMENT

Examination of available documents and a visual inspection of the dam revealed conditions which if not corrected constitute a hazard to human life or property.

Using the Corps of Engineers screening criteria for review of spillway adequacy, it has been determined that the dam would be overtopped by all storms exceeding approximately 34 percent of the PMF. The overtopping of the dam could cause erosion in the notched earthen section adjacent and parallel to the concrete Ogee weir resulting in possible undermining and failure of the spillway. Failure of the spillway would result in an increased hazard to the loss of life and property downstream. The spillway is, therefore, judged as "seriously inadequate" and the dam is assessed as unsafe, non-emergency.

The classification of "unsafe" applied to a dam because of a "seriously inadequate" spillway is not meant to imply the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, there appears to be a serious deficiency in the spillway capacity and if a severe storm were to occur, overtopping and possible failure of the spillway and dam could take place, thereby significantly increasing the hazard to loss of life downstream of the dam.

Structural stability analysis based on available information and the visual inspection indicates that the stability of the spillway section against overturning and sliding is inadequate for nealy all loading conditions other than those when the reservoir is at the spillway crest.

Seepage was detected adjacent to the spillway and in the downstream slope of the west embankment. A wet area was observed along the downstream slope of the east abutment-embankment contact of the east embankment. Those wet areas and seeps could seriously affect the stability of the spillway and embankment.

It is, therefore, recommended that within 3 months of notification to the owner, detailed hydrologic/ hydraulic investigation of the structure should be undertaken to better determine the site specific characteristics of the watershed and their affect upon potential overtopping of the dam. The results of these investigations will determine the appropriate remedial measures which will be required to achieve a spillway capacity adequate to discharge the outflow from at least one-half the PMF. A detailed field investigation and monitoring program should be undertaken to determine the source of seepage and the wet areas noted above. At the same time a detailed investigation should be performed to determine the structural stability of the spillway and slope stability of the downstream embankment slopes.

At this time we do not recommend the trees be removed from the embankment slopes unless provisions are made to drain and protect these slopes using a granular drainage blanket. Indiscriminate cutting of trees could result in serious sloughing of the slopes.

In the interim, a detailed emergency action plan must be developed and implemented providing around-the-clock monitoring of the structure and provisions for notification of downstream residents during periods of unusually heavy precipitation.

In addition, the dam has a number of deficiencies which, if left untreated, could increase the potential for hazardous conditions to develope. These deficiencies should be corrected within the first construction season following notification of the owner. The deficiencies and recommneded measures are as follows:

1) Restore spillway retaining walls to the lines and grades of the original construction

2) Bench, place and compact any embankment slips or sloughs

3) Place and compact embankment type material along all eroded embankment-abutment contacts

4) Provide erosion protection along abutment-embankment contacts and the berm on the west embankment downstream slope

5) Place and compact embankment type material adjacent to the spillway crest where the level of existing grades is below the top of the retaining wall (see as-built drawing in Appendix G - Survey by Thomsen Associates-1980)

6) Place and compact embankment material where the concrete corewall is exposed and regrade west embankment crest to the elevation and dimension of the east embankment crest

7) Remove all debris from spillway

8) Patch and fill all cracks in the spillway

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26 SEP 1980

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APPROVED BY:

New York District Engineer
Colonel W. M. Smith, Jr.

View of Spillway & Spillway Exit
channel from east embankment.
Note: Inward movement of Wingwall and erosion behind Wingwall,
log in spillway.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
FREDONIA RESERVOIR
I.D. No. N.Y. 749
LAKE ERIE BASIN
CHAUTAUQUA COUNTY, NEW YORK

SECTION 1: PROJECT INFORMATION

1.1 GENERAL

a. Authority

This Phase I Inspection Report was authorized by the New York State Department of Environmental Conservation by Contract No. D-201458. This study was performed in accordance with the terms of the above contract and the Recommended Guidelines for Safety Inspection of Dams prepared by the Department of Army, Office of the Chief of Engineers to fulfill the requirements of the National Dam Inspection Act, Public Law 92-327.

b. Purpose of Inspection

This inspection was conducted to obtain available data concerning design and construction of the dam, to evaluate that data, to visually inspect existing conditions at the dam, to identify and evaluate deficiencies and/or hazardous conditions which, if present, may threaten life and property of the residents downstream of the dam and to recommend remedial measures to mitigate such deficiencies and hazardous conditions.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam

The Fredonia Reservoir dam consists of two separate earth embankments and a central concrete Ogee spillway. Both embankments are constructed of a "rolled" mixture of silt, sand and clay and have a crest width of 11 feet.

The west embankment is constructed on the downstream slope of a former embankment and has an embankment length of 270 feet with a maximum height above the original ground surface of 80 feet. The upstream slope is 1 vertical on 6 horizontal with the former embankment crest acting as a berm at elevation 1021.0. The downstream slope is 1 vertical on 2.3 horizontal with a stone lined gutter at about elevation 1011.0. The east embankment is constructed at the location of the former spillway associated with the buried embankment noted above. This embankment is 260 feet long and has a maximum height of about 50 feet. The upstream slope is 1 vertical on 5 horizontal with a downstream slope of 1 vertical or 2 horizontal.

A rockfilled section is constructed at the downstream toe of both embankments. Likewise both embankments are provided with concrete corewalls with concrete cutoff walls and steel sheet pile walls keyed into either the bedrock or "hard impervious clay".

A series of stone underdrains were constructed under the embankment from the rockfill toe towards the corewall (see "plan" in Appendix G).

The spillway is an uncontrolled concrete Ogee weir with the crest at elevation 1036.0 and a weir length of 75 feet. The approach apron is 4 feet below the crest elevation and the exit channel slopes away from the Ogee section at a 2 percent slope for a distance of 90 feet. The exit channel gradually narrows from the spillway crest to a width of 40 feet. The remainder of the spillway structure from the end of the exit apron to the tailwater elevation is constructed in a tread and riser (i.e., stepped) fashion with an average slope of 1 vertical on 1.1 horizontal.

The tailwater elevation is maintained by a masonry dam in the downstream channel which was notched (partially breached) as part of the construction in 1937. The tailwater elevation at the time of the inspections was about 967±.

A notched earthen section parallels the concrete spillway. This notched section rises from the top of the spillway retaining walls which is at elevation 1042.0 along the spillway crest centerline to the dam crest at elevation 1044.8. A cross-section of the existing spillway profile along the spillway crest centerline is shown on a drawing in Appendix G.

The reservoir can be drained to about elevation 1016 by a 12 inch cast iron intake water pipe with a tee-section to a "blowoff" valve. The gate valve is manually operated.

b. Location

The Fredonia Reservoir Dam is located about 3.2 miles southeast of the village of Fredonia and 2 miles south of the village of Laona, New York.

c. Size Classification

The dam has a maximum height of 80 feet and an estimated total storage capacity of 1524 acre-feet at the top of the dam. Therefore, the dam is of intermediate size by virtue of its height and storage capacity.

d. Hazard Classifications

The dam is classified as a high hazard structure due to the number of homes, businesses and bridges along the downstream channel.

e. Ownership

The dam is owned by the village of Fredonia, New York. The village engineer, Mr. George Nutbrown, was contacted as part of the Phase I inspection. Mr. Nutbrown's address is Village Hall, Temple and Church Street, Fredonia, New York and his telephone number is 716-679-4741.

f. Purpose of the Dam

The purpose of the dam is to impound and store the village of Fredonia water supply.

g. Design and Construction History

The design of the dam was performed by Fretts, Tallamy and Senior, Consulting Engineers of Williamsville, New York. The dam was constructed about 1937 by the Works Progress Administration.

Prior to construction of the present dam the site was formerly occupied by at least two other dams. The newer of these dams was of similar construction (i.e. earth embankment with concrete corewall) to the present dam but had its crest at elevation 1021.0 and was located upstream of the existing west embankment.

The 1915 Dam Report submitted to the State of New York Conservation Commission indicates another dam of masonry construction was situated upstream of the present east embankment. This dam was constructed around 1896 and was extensively repaired in 1912 when it was partially breached. The masonry dam may have been renovated to form the spillway of the earth embankment dam presently buried by the existing west embankment.

h. Normal Operations Procedures

Normal flows are discharged over the concrete spillway. The elevation of the spillway crest is 1036.0 based on the pool elevation shown on the 7 1/2 minute U.S.G.S. Dunkirk, New York quadrangle. All discharge passes through the spillway until the reservoir level exceeds elevation 1042.0. The spillway has sufficient capacity to discharge 34 percent of the Probable Maximum Flood (PMF) without discharge occurring in the notched earthern section adjacent to the spillway. The dam, however, would be overtopped by all storms exceeding 67 percent of the PMF.

1.3 PERTINENT DATA

a. Drainage Area (sq. mi.)	5.55
b. Discharge at Damsite (cfs)	
Reservoir Drain at Spillway Crest	21
Spillway (flow only through concrete section Elev. 1042.0)	4234
Combined Spillway and Notched Earth Section at Top of Dam (Elev. 1044.8)	8292
c. Elevation (ft. above MSL)	
Spillway Crest and Normal Pool	1036.0
Top of Dam	1044.8
d. Storage (acre-feet) (as taken from Application for Construction, See Appendix E)	
Normal Pool	1024
f. Flood Storage (acre-feet)	
Top of Concrete Spillway Section (Elev. 1042)	320
Top of Dam (Elev. 1044.8)	497
g. Reservoir Surface (acres)	
Normal Pool	48
Top of Dam	65
h. Dam (as taken from design drawings)	
Type: The dam is an earth embankment with a concrete corewall	
Length: (ft.)	
East Embankment:	260
West Embankment:	270
Height: (ft.)	
East Embankment:	50
West Embankment:	80
Top Width: (ft.)	11

Upstream Slope: (V:H)

East Embankment:	1:5
West Embankment:	1:6

Downstream Slope: (V:H)

East Embankment:	1:2
West Embankment:	1:2:3

Cutoff: Concrete corewall with concrete cutoff trench in rock in maximum sections of dam and steel sheet piles toward abutments and below the spillway

Grout Curtain:	None

i. Spillway

Type: Concrete Ogee weir with crest elevation at 1036.0. Entrance (approach) channel 4.0 feet below crest and a 90 foot concrete exit channel on a 2 percent slope.

Length of Weir:	75 feet
Minimum Width of Exit Channel:	40 feet

j. Reservoir Drain

Type: 12 inch diameter cast iron pipe

Length:	670 feet

Control: Manually operated gate valve near exit portal of tunnel to intake structure

SECTION 2: ENGINEERING DATA

2.1 GEOTECHNICAL DATA

a. General Geology

The Fredonia Reservoir and dam are located approximately three miles south of Fredonia, New York on the rim of the Allegheny Plateau.

Local bedrock consists of interbedded shales and siltstones of Upper Devonian age which have been uplifted and dissected. Although a regional dip southward at a gentle rate may be discerned, these strata are essentially flat-lying over short distances. No major or active faults are known to exist in the area.

The Village of Fredonia and Fredonia Reservoir are situated in a region classified as Zone 3 seismicity, as shown on Figure No. 1 of the Recommended Guidelines for Safety Inspection of Dams.

Pleistocene glaciation has modified the topography by means of both erosion and deposition. The continental ice sheet advanced and receded repeatedly in southwestern New York, smoothing terrain by glacial scour and mantling the uplands with stony till deposits. Glacial valleys were filled with lacustrine sediments and subsequently, by granular stratified outwash; such is the case in the Canadaway Creek Valley.

The Pleistocene geology of the immediate dam site is that of glacial lake sediments as shown on a portion of the map titled "Pleistocene Geology of Chautauqua County, New York" by E. H. Muller, New York State Museum and Science Service Bulletin 391, which is contained in Appendix G.

In Holocene (recent) times, soil profiles have developed on these glacial deposits and infilling of valleys with alluvial material eroded from the uplands has continued.

b. Subsurface Conditions

The only available data concerning the subsurface conditions at the dam site is that shown on the design engineering drawings included in Appendix G.

2.2 DESIGN RECORDS

The dam was designed by Fretts, Tallamy and Senior, Consulting Engineers of Williamsville, New York who prepared a "Report of Proposal to Increase Reservoir Capacity for Fredonia, New York" and prepared engineering drawings for the construction of the dam and appurtenant structures. Appendix E contains portions of the above report.

2.3 CONSTRUCTION RECORDS

No construction records were available, however, it is noted the actual construction of the spillway is different from what the engineering drawings indicate. The spillway centerline was surveyed as part of the Phase I inspection and the cross-section shown in Appendix G is different than the design cross-section also contained in Appendix G.

In 1966 modifications were made to the reservoir drain "blow-off" valve, intake structure and regrading along the spillway. This work was part of a large contract for construction of an addition to the Water Filtration Plant. This project was designed by Bissell, Bronkie and Associates, Consulting Civil Engineers of Williamsville, New York. Those drawings pertaining to the regrading adjacent to the spillway are included in Appendix G.

2.4 OPERATION RECORDS

The dam is designed as an uncontrolled water storage structure, therefore no operating records are maintained regarding reservoir level or spillway discharge.

2.5 EVALUATION OF DATA

The data presented in this report has been compiled from information obtained from the Village of Fredonia and the files of the New York State Department of Environmental Conservation.

The data reviewed indicated a number of discrepancies between the design and as-built features of the dam. In addition, both the dam designers and filtration plant addition designers used a different datum for vertical control, both of which do not correspond to the U.S.G.S. datum.

In general, the data is considered adequate and reliable.

SECTION 3: VISUAL INSPECTION

3.1 FINDINGS

a. General

A visual inspection of the dam was conducted on May 14, May 15, and May 22, 1980. The weather at the time of the initial inspection was cloudy and rainy which resulted in the reinspection on May 15, 1980 during clear and warm weather to better observe any evidence of seepage. The purpose of the May 22, 1980 inspection was to operate the reservoir drain gate valve. The reservoir level during all inspections was at the crest of the spillway.

b. Embankment

The embankment sections are heavily wooded, and based on the size of some trees, the embankments have apparently been wooded at least 20 years. The only area not tree covered is the crest of the east embankment and the relatively flat cut area east of the spillway. The grouted stone gutters along the embankment-abutment contacts are badly eroded and/or missing entirely resulting in erosion and gully development. The downstream slopes of both embankments exhibit signs of surface creep as evidenced by numerous bowed tree trunks. A surface slough was detected on the downstream slope of the west embankment above the stone gutter-berm near the east abutment-embankment contact.

The west embankment crest was crown shaped and slopes away from the exposed and deteriorated top of the concrete corewall. The horizontal and vertical alignment of the east embankment was satisfactory.

Seepage was emerging from the downstream slope of the west embankment 3 to 5 feet above the rockfilled toe from near the center of the embankment to the west embankment-abutment contact. The line of seepage occurred along the same elevation and is estimated to be less than 5 gallons per minute.

Flowing water was detected along the west embankment-abutment contact of the east embankment on the lower half of the downstream slope. The source of the water could not be determined and may represent seepage or surface run-off due to precipitation on the day preceding the inspection.

c. Spillway

During the inspection all of the spillway was exposed except the upstream face of the weir and the concrete approach apron.

Both retaining walls (wingwalls) of the spillway have undergone inward movement in the past. The east wall has experienced between 1 1/2 and 6 inches of movement at the top of the wall, whereas, the west wall movement is on the order of 1 to 2 inches. Both walls have exposed steel anchor plates which are part of some type of tie back system used to stabilize the wall movement. Details of the tie back were not available. Each wall has a total of seven anchor plates spaced approximately 9 feet apart.

In general, the concrete surfaces are in good condition. A few construction joints need repair to refill the joints and a minor crack has occurred along the construction joint at the intersection of the exit channel and lower nappe of the Ogee section near the west retaining wall.

Significant structural cracking has occurred in the retaining walls due to the wall rotation.

Erosion has occurred behind the east retaining wall 100 feet downstream of the spillway crest. A slight amount of debris was present in the exit channel.

Seepage was emerging from the embankment side of the spillway west retaining wall at approximately elevation 1012. The water flowing from this concentrated seep was clear and the quantity was estimated to be less than 5 gallons per minute. Two 1 to 1 1/2 inch diameter black plastic pipes were present at the site of the seep.

d. Notched Earth Section

A notched earth section is on both sides of the spillway. The notched section slopes upward from the top of retaining wall at elevation 1042.0 to the top of the dam at elevation 1044.8 along the spillway crest centerline. East of the spillway the notched section is grass lined, whereas west of the spillway the area is tree covered.

e. Reservoir Drain

The reservoir is drained by a 12 inch cast iron pipe attached to one of the 12 inch water intake pipes which conveys water from the intake structure to the water filtration plant. The reservoir is drained by opening a 12 inch gate valve which is connected to the water intake pipe by a 12 inch tee and then closing a similar valve on the water intake pipe. The reservoir water is discharged into the downstream channel below the partially breached masonry dam. The "blow off" gate valve is in operable condition and was operated on May 22, 1980.

f. Downstream of Toe

The area downstream of both embankments is quite flat and several inches of a rust colored water covered the surface at the time of the inspection. These areas are brush covered and occasionally heavily wooded.

g. Downstream Channel

The downstream channel is in a very steep ravine with rock outcrops along the lower quarter of the slopes. The partially breached masonry dam in the downstream channel maintains the tailwater during normal spillway discharge near elevation 967. Downstream of the masonry dam the channel is still quite steep and bedrock forms the stream bed.

h. Reservoir Area

The area surrounding the reservoir is forested with moderate to steep slopes. No signs of instability were observed.

3.2 EVALUATION

The visual inspection of this dam revealed that the notched earthen section was not constructed with the crest elevations as originally designed. Therefore, the spillway notched earthen section and embankment was surveyed to determine the actual profile.

In addition, the following deficiencies were observed:

a. Seepage

1) Seepage emerging from downstream slope of west embankment
2) Seepage emerging from west side of spillway
3) Water flowing in west abutment-embankment contact on downstream slope of east embankment

b. Spillway

1) Rotational movement of spillway retaining walls along exit channel
2) Erosion behind east spillway retaining wall
3) Minor cracks in spillway exit channel base
4) Debris in spillway

c. Embankment

1) Surface sloughing on west embankment downstream slope
2) Surface creep on downstream embankment slopes
3) Heavily wooded embankments
4) Erosion gullies along embankment-abutment contacts
5) Deteriorated condition of exposed concrete along west embankment corewall
6) Horizontal alignment of west embankment crest

SECTION 4: OPERATION AND MAINTENANCE PROCEDURES

4.1 PROCEDURES

The normal reservoir level is controlled by the crest elevation of the concrete Ogee spillway. Downstream flow is limited by the flow over the spillway. The reservoir has sufficient capacity to store and discharge over the spillway 34 percent of the PMF without discharge occurring in the notched earthen section. The dam is overtopped by all storm events exceeding 67 percent of the PMF.

4.2 MAINTENANCE OF DAM

The responsibility for maintaining the dam is the Village of Fredonia. From the present condition of the dam it is obvious little or no maintenance has occurred.

4.3 WARNING SYSTEM IN EFFECT

There is no warning system or evacuation plan in effect.

4.4 EVALUATION

The operation procedure for this structure is satisfactory. A formal maintenance program is necessary and should be implemented within 3 months from the time of notification to the owner.

SECTION 5: HYDROLOGIC/HYDRAULIC

5.1 DRAINAGE AREA CHARACTERISTICS

Delineation of the watershed draining into the reservoir pool area was made using the U.S.G.S. 7.5 minute quadrangles for Dunkirk and Cassadaga, New York. The drainage area measures 5.55 square miles and consists predominantly of wooded land along with some open fields. The relief in the area consists of moderate to steep sloped hills that surround the reservoir to the east, west and south.

5.2 ANALYSIS CRITERIA

The analysis of the floodwater retarding capacity of this dam was performed using the Corps of Engineers HEC-1 computer program, Dam Safety Version. This program develops an inflow hydrograph based upon the "Snyder Snythetic Unit Hydrograph" and then uses the "Modified Puls" flood routing procedure. The spillway design flood selected for analysis was the PMF in accordance with the Recommended Guidelines of the U.S. Army Corps of Engineers.

5.3 SPILLWAY CAPACITY

The Fredonia Reservoir spillway structure consists of a 75 foot long Ogee concrete weir that is situated approximately in the center of the dam. The spillway crest elevation is at 1036 feet above mean sea level. The discharge over the spillway was computed assuming the coefficient of discharge 'C' varies with the height of head 'H' over the spillway. The discharge was also adjusted due to tailwater submergence. The spillway does not have sufficient capacity for discharging the peak outflow from the Probable Maximum Flood (PMF). For the PMF, the peak inflow is 12,811 cfs and the peak outflow is 12,760 cfs. For one-half the PMF, the peak inflow is 6,405 cfs and the peak outflow is 6,151 cfs. The computed spillway capacity for flow within the concrete spillway and the reservoir at elevation 1042.0 is 4234 cfs.

5.4 RESERVOIR CAPACITY

The flood storage capacity (above normal pool) of the reservoir at the top of dam is 497 acre-feet which is equivalent to a runoff depth of 1.68 inches of rain over the entire drainage area.

5.5 FLOODS OF RECORD

Due to the lack of reliable information, no attempt was made to estimate the discharge of the flood of record.

5.6 OVERTOPPING POTENTIAL

Analysis using the PMF indicates that the dam does not have sufficient spillway capacity. For a PMF peak outflow of 12,760 cfs, the dam would be overtopped to a computed depth of 1.18 feet. The dam would be overtopped by all storms exceeding 67 percent of the PMF and discharge would occur in the notched earthen section adjacent to the spillway for all storms exceeding 34 percent of the PMF.

5.7 EVALUATION

Using the available data, the spillway is capable of discharging approximately 34 percent of the PMF. Outflow in excess of 34 percent of the PMF would discharge through the spillway and the notched earthen section adjacent to the spillway. For discharges in excess of 67 percent of the PMF the dam would be overtopped.

The notched earthen section is not protected, therefore, the potential for erosion and possible undermining of the spillway exists.

SECTION 6: STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

The present condition of the spillway retaining walls are considered marginally stable. Portions of the retaining wall have undergone rotational movement at the top of wall between 1 and 6 inches. This magnitude of movement may well have overstressed the reinforcing steel which ties the wall to the foundation.

b. Design and Construction Data

No records concerning structural stability analyses were available for review.

A review of the engineering drawings in accordance with recommended design parameters* for earth embankments of "compacted" sand, silt and clay indicates adequate factors of safety against embankment shear failure for the upstream slope of both embankments.

The downstream embankment slopes, however, are fairly steep for homogeneous downstream earth embankment construction. As the condition of the concrete corewall and cutoff trench can not be evaluated, and the composition of the downstream embankment section is unknown, the actual stability of the downstream embankment slopes is also unknown. Therefore, it is recommended that additional investigations and analyses be performed to determine the stability of the downstream embankment slopes.

A stability analyses was performed on the concrete spillway. Cross-sections of the spillway shown in the engineering drawings in Appendix G were used to perform this analysis. The following cases with varying loading conditions were analyzed.

---

*"Design of Small Dams", U.S. Department of Interior, Bureau of Reclamation, 1977.

a. Normal Pool with the reservoir at the spillway crest

b. One half PMF, water flowing over the spillway crest at a depth of 7.5 feet

c. PMF, water flowing over the spillway crest at a depth of 9.98 feet.

The basis of the analysis is contained in Appendix D and is summarized in the table on the following page.

The analyses indicates sliding safety factors, for the strength parameters selected, are below the recommended minimum safety factor of 3 for nearly all loading conditions without earthquake, and 1.5 when earthquake loading is included. For overturning stability, the analysis indicates the resultant of the applied forces is outside the middle third of the spillway crest section for most cases of half and full PMF as well as several conditions at normal pool elevation. The one major overturning force which can not be accurately evaluated is that of hydrostatic uplift. For this reason it is recommended that the actual distribution and magnitude of the hydrostatic uplift pressures be determined and based on these results additional structural stability analyses be performed.

c. Seismic Stability

The dam is situated in Seismic Zone 3, therefore, a seismic stability analyses was performed using the Zanger hydrodynamic pressure distribution which is similar to the Westergaard distribution recommended by the Corps of Engineers guidelines. The analysis was performed under normal pool, half PMF and full PMF. The results are tabulated on the following page and these indicate the spillway is marginally stable under all conditions except maximum ice load (10 kips) at normal pool and the PMF storm event.

FREDONIA RESERVOIR SPILLWAY
SUMMARY OF STABILITY ANALYSES

CASE	LOADING CONDITIONS				FACTOR OF SAFETY		Resultant Within Middle 1/3	Resultant Within Base
	Full Uplift	1/2 Uplift	Ice	Seismic (Zone 3)	Overturning	Sliding		
Normal		X	X		1.20	1.16	No*	Yes
	X		X		1.01	1.08	No*	Yes
	X		X	X	0.97	0.95	No	No*
		X	X	X	1.14	1.02	No	Yes
	X				2.81	13.1	Yes	
		X			4.92	14.1	Yes	
1/2 PMF	X				1.28	2.19	No*	Yes
	X			X	1.20	1.57	No	Yes
		X			2.07	2.55	Yes	
		X		X	1.85	1.83	Yes	
PMF	X				1.09	1.64	No	Yes
	X			X	1.02	1.23	No	Yes
		X			1.74	1.97	Yes	
		X		X	1.57	1.48	No	Yes

*Resultant of applied loads falls outside middle 1/3 for non-seismic loadings and outside base for seismic loadings.

SECTION 7: ASSESSMENT/RECOMMENDATIONS

7.1 ASSESSMENT

a. Safety

The Phase I inspection of the Fredonia Reservoir Dam revealed numerous conditions which, if left uncorrected, could constitute a hazard to human life and property of the downstream residents.

From the available data the spillway is capable of discharging 34 percent of the PMF without flow occurring in the notched earthen section. The spillway is, therefore, judged to be "seriously inadequate" and the dam considered to be unsafe, non-emergency.

Existing conditions observed during the visual inspection revealed problems which could jeopardize the integrity of the structure. The conditions are as follows:

1) Rotational inward movement of the concrete spillway retaining walls
2) Seepage exiting the west side of the spillway and on the downstream slope of the west embankment
3) Water flowing in the lower half of the downstream slope at the west abutment-embankment contact of the east embankment could constitute a serious problem if the source of this water is from seepage through the embankment or along the abutment-embankment contact

The structural stability analyses performed as part of this investigation indicates the spillway is not stable against sliding or overturning for nearly all loading conditions.

The downstream embankment slopes are, in our opinion, steeper than would presently be recommended for embankment materials composed of a silty clay, which we believe to be the case.

b. Adequacy of Information

The information which was reviewed is considered to be adequate for Phase I study purpose.

c. Need for Additional Inspection

Additional investigation, monitoring and analyses are required for this structure because of the conditions and deficiencies disclosed by this Phase I inspection. These investigations and analyses are grouped into three (3) seperate study areas, all of which are interrelated. The study areas and specific tasks within each study area are as follows:

1) Study Area No. 1 - Perform a detailed hydrologic/hydraulic investigation and analysis of this structure

    o Determine the site specific characteristics of the watershed and their affect upon the overtopping potential of the dam

    o Determine appropriate remedial measures to achieve a spillway capacity cabable of discharging the outflow from 1/2 the PMF

2) Study Area No. 2 - Perform a detailed investigation and analysis of the structural stability of the spillway

    o Determine the magnitude and distribution of the hydrostatic uplift pressure perpendicular to the spillway

    o Determine the source of seepage west of the spillway emerging near elevation 1021± and the appropriate remedial measures to correct or mitigate this deficiency

    o Determine the cause of the distress and resulting rational movement of the spillway retaining walls and provide recommendation(s) to correct this condition

    o Determine the soil strength parameters (C&ϕ) for those soils which affect the structural stability of the spillway

3) Study Area No. 3 - Perform a detailed investigation and analysis of the embankment downstream slope stability

   - Determine the source of seepage through the west embankment, the source of water observed to be flowing in the west abutment-embankment contact of the east embankment and provide the appropriate recommendation(s) to correct these conditions
   - Determine the location of the phreatic surface in the embankment and the soil strength parameters (C&Φ) of the embankment and foundation materials
   - Provide the appropriate recommendations based on the slope stability analysis. These recommendations should also consider the influence of removing the existing heavy tree cover and methods of stabilizing the surface creep and surface sloughing problem which presently exists and could be further aggrevated by indiscriminate tree removal

d. Urgency

The above studies and investigations should be initiated within 3 months and completed within 18 months after notification has been made to the owner.

7.2 RECOMMENDED REMEDIAL MEASURES

a. General

Develop and implement within 3 months a monitoring and warning system for the structure as well as an evacuation plan for downstream residents in the event of large spillway discharge.

b. Specific Areas

The following deficiencies should be corrected within the first construction season following notification to the owner.

1) Spillway

   - Restore spillway wingwalls to original construction
   - Patch and fill all cracks in the spillway
   - Remove debris from spillway

2) Embankments

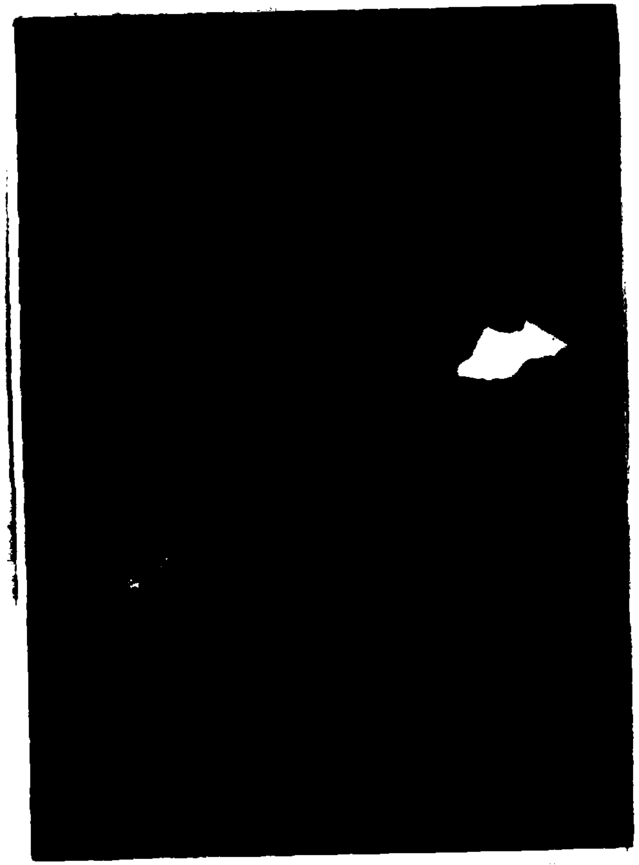
- Place and compact embankment type material along all eroded embankment-abutment contacts
- Provide erosion protection along abutment-embankment contacts and the berm on the west embankment downstream slope
- Bench, place and compact any embankment slips or sloughs
- Place and compact embankment type material adjacent to the spillway crest where the level of existing grades is below the top of the retaining wall (see as-built drawing in Appendix G - Survey by Thomsen Associates-1980)
- Place and compact embankment material where concrete corewall is exposed and regrade west embankment crest to the elevation and dimension of the east embankment crest

c. Future Remedial Measures

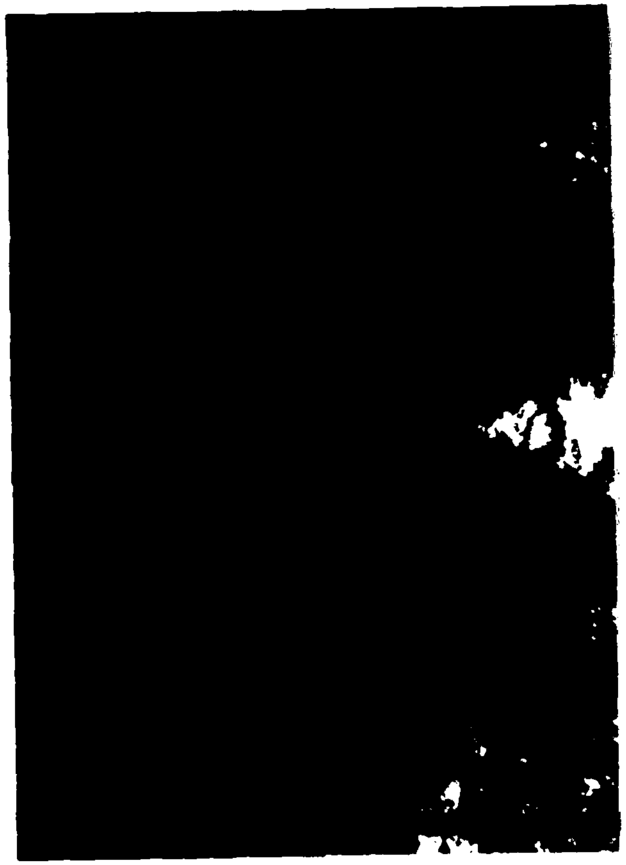
Those remedial measures recommended as a result of the additional investigations noted in Section 7.1 should be completed within the first construction season following the completion of the additional investigation.

APPENDIX A

PHOTOGRAPHS

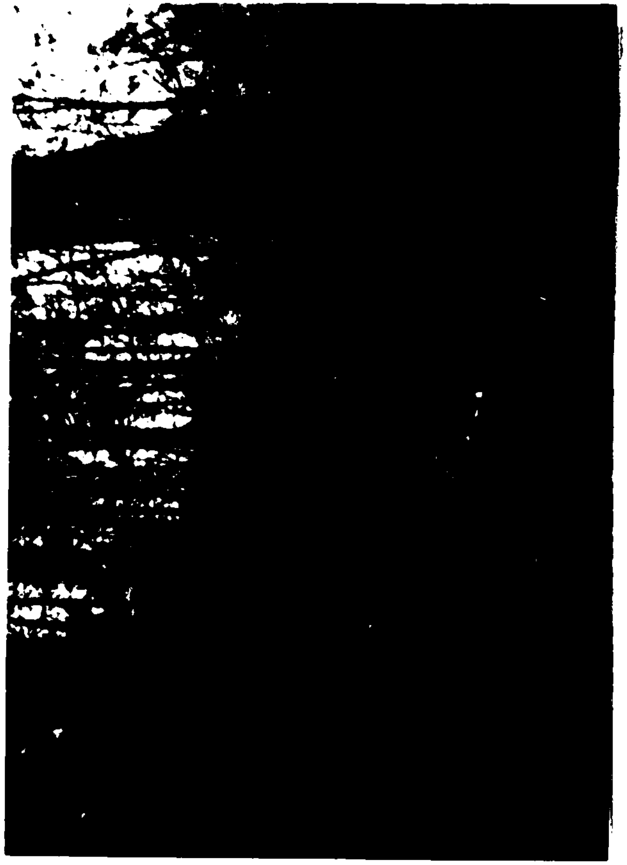


View of Downstream Slope-East Embankment
Note: Trees on Slope

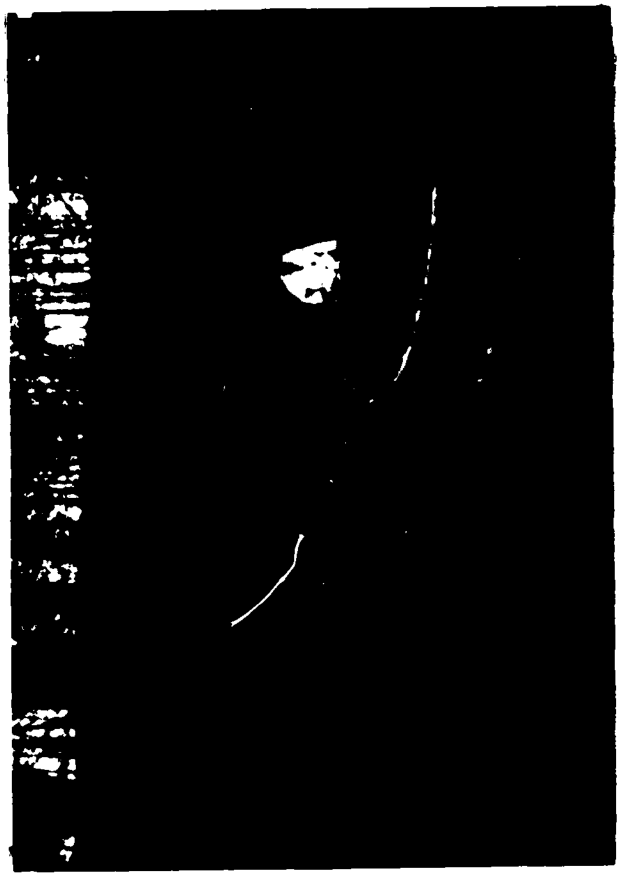


View of Crest-East Embankment
Note: Upstream Slope-Right hand side of Photo
Downstream Slope-Left hand side of Photo

View of Upstream Slope-East Embankment
Note: Trees on Slope

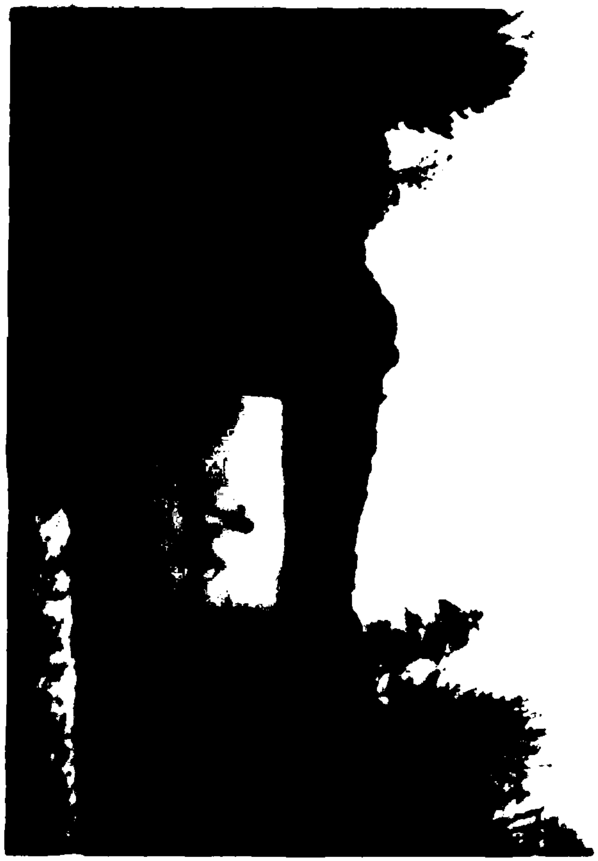


View of Downstream Slope-East Embankment from East Embankment-Abutment Contact.Note: Bowed tree trunk near center of photo. (Evidence of Surface Creep)

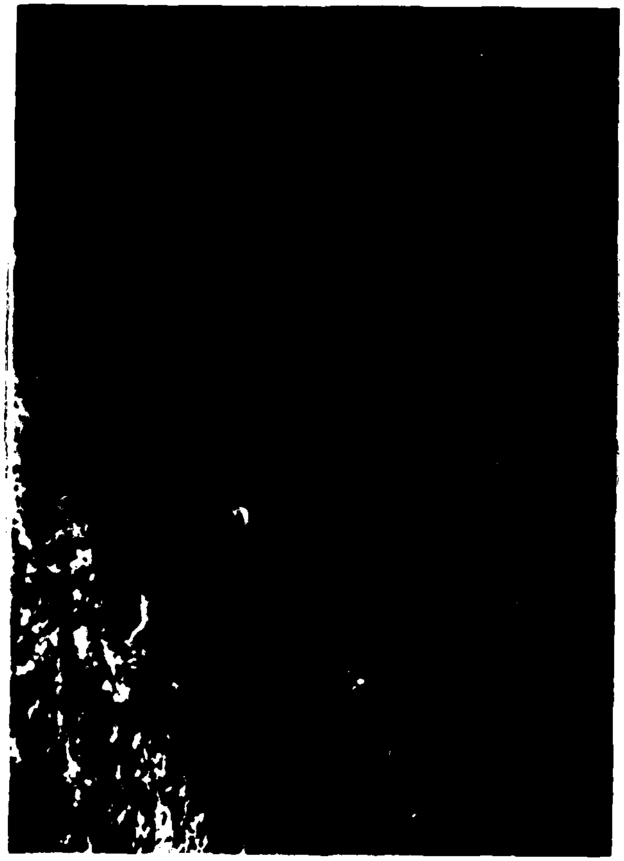


View of Downstream Slope and Rock Fill at Toe of East Embankment, Note: Trees on Slope and in Rock Fill, Rust Colored Standing Water at Toe of Rock Fill.

View of Downstream Slope and Rock Fill at Toe of West Embankment, Note: Trees on Slope and in Rock Fill, Rust Colored Standing Water at Toe of Rock Fill.

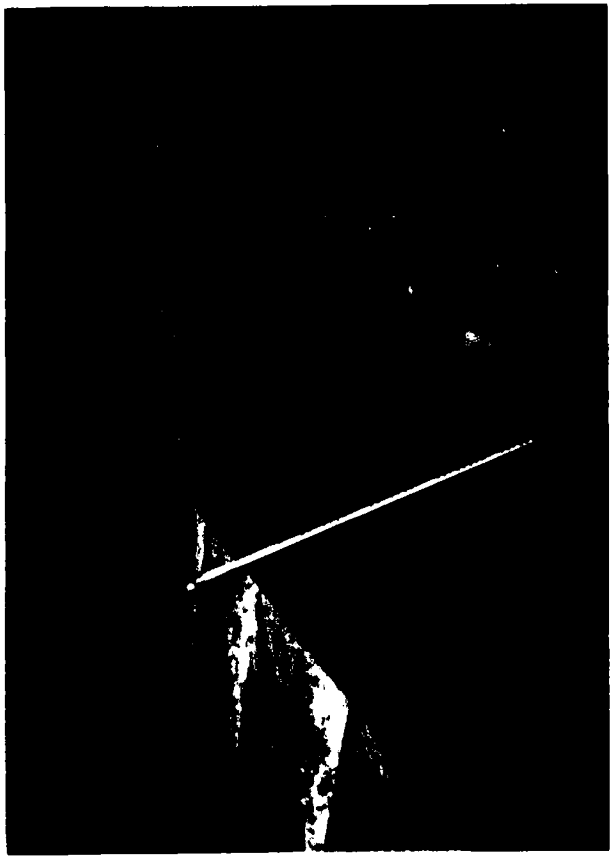


[illegible] EXIT [illegible] embankment. [illegible] walls, [illegible]



View of Downstream Slope-West Embankment. Note: Seeps emerging from embankment at toe of the rock filled toe.

View of Downstream Slope-West Embankment, Evidence of Surface Sloughing-Note: Scarp in Center of Photo with toe of surface slough in lower right hand corner [illegible] where tree is at lower.

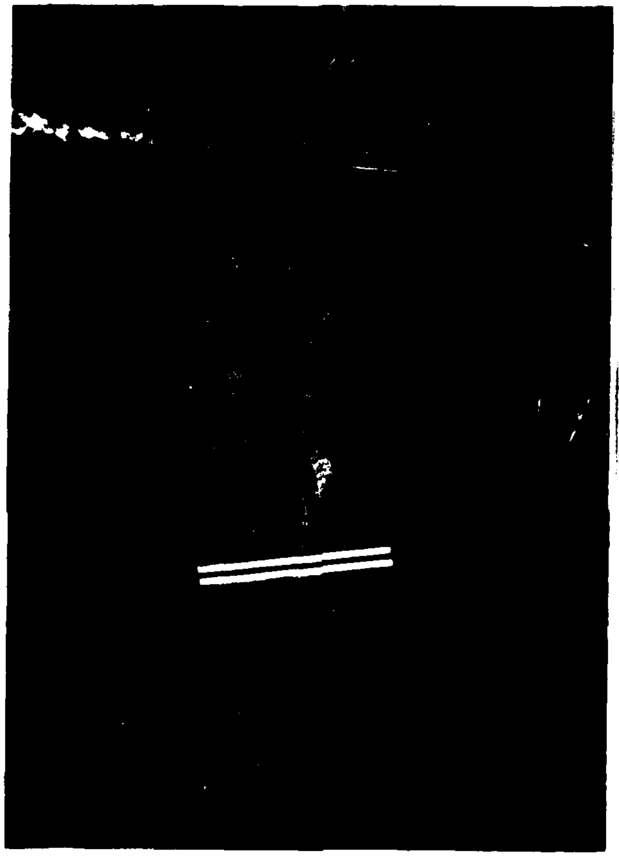


View of Erosion behind east Wing wall of Spillway exit channel
Note: Movement of Wingwall

View of Erosion Behind west wingwall of Spillway Entrance Channel.

View of East Wingwall of Spillway Exit Channel Note: Bearing Plates of Tie Back System used to minimize wall movement.

View Looking Downstream of Stepped Spillway Channel to Tailwater.



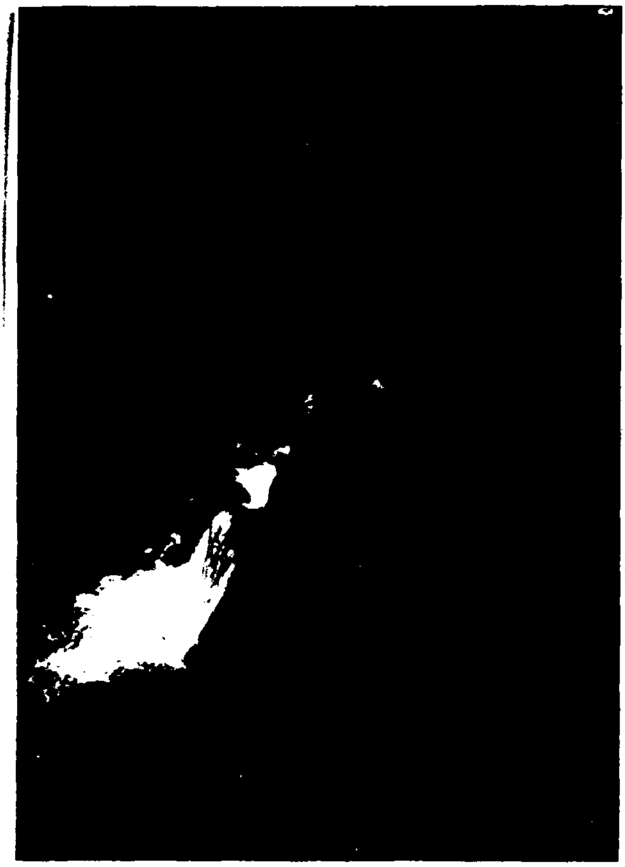
View of Crack in East Spillway Wingwall.

View of Crack in Spillway Exit Channel.

View of Stepped Spillway Channel.

View of Downstream Channel below Spillway Note: Structure in Center of Photo is abandoned Intake Structure for Breached Masonry Stone Dam.

View of Downstream Portal for Rock Tunnel under East Embankment: Tunnel has Intake Pipes to Filtration Plant and Reservoir Drain Pipe.



View of Downstream Face of Breached (Notched) Masonry Stone Dam which controls the tailwater elevation of Fredonia Reservoir.

APPENDIX B

VISUAL INSPECTION CHECKLIST

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CONSULTING GEOTECHNICAL ENGINEERS & GEOLOGISTS

VISUAL INSPECTION CHECKLIST

1) Basic Data

a. General

Name of Dam Fredonia Reservoir
I.D. # [illegible] DEC. Dam No. NY [illegible]
River Basin Lake Erie
Location: Town Pomfret County Chautauqua
U.S.G.S. Quadrangle Dunkirk
Stream Name West Branch Canadaway Creek
Tributary of Canadaway Creek
Latitude (N) 42°23.3' Longitude (W) [illegible]
Type of Dam Earth Embankment w/ Concrete Corewall, [illegible]
Hazard Category High
Date(s) of Inspection [illegible]
Weather Conditions [illegible]
Reservoir Level at Time of Inspection [illegible]
Tailwater Level at Time of Inspection [illegible]

b. Inspection Personnel [illegible]
[illegible]

c. Persons Contacted (Including Address & Phone No.)
Mr. [illegible] - Village of Fredonia [illegible]
Village Hall, [illegible] & Church St., Fredonia, N.Y.
[illegible]

d. History:
Date Constructed 19[illegible] Date(s) Reconstructed

Designer [illegible]
Constructed by W.P.A.
Owner Village of Fredonia, New York

e. Seismic Zone Zone 2

VISUAL INSPECTION CHECKLIST

2) Embankment

a. Characteristics

1) Embankment Material East Fill - [illegible] West
Fill - Silty Clay

2) Cutoff Type [illegible] Cutoff [illegible]
Plan Sections, See Sheet Nos (SP-4-16") [illegible]

3) Impervious Core [illegible]

4) Internal Drainage System [illegible]

5) Miscellaneous

b. Crest

1) Vertical Alignment East - OK, West - OK

2) Horizontal Alignment East - OK, West - [illegible] & [illegible]
away from exposed [illegible] Ground

3) Surface Cracks None Observed

4) Miscellaneous

c. Upstream Slope

1) Slope (Estimate) (V:H) East - [illegible], West [illegible]

2) Undesirable Growth or Debris, Animal Burrows East [illegible]
[illegible] West [illegible]

3) Sloughing, Subsidence or Depressions None [illegible]

VISUAL INSPECTION CHECKLIST

4) Slope Protection None

5) Surface Cracks or Movement at Toe [illegible]

d. Downstream Slope

1) Slope (Estimate - V:H) East - 1:2, West - 1:[illegible]
2) Undesirable Growth or Debris, Animal Burrows East [illegible] West Embankment [illegible] both [illegible]
3) Sloughing, Subsidence or Depressions [illegible]
West Emb. - [illegible] near East [illegible]
4) Surface Cracks or Movement at Toe [illegible]
5) Seepage East - None [illegible], West - [illegible] west abutment
6) External Drainage System (Ditches, Trenches; Blanket)
[illegible]
East side - Gutters [illegible]
WEST side - Gutters [illegible]
7) Condition Around Outlet Structure OK - [illegible] along West Side of Spillway
8) Seepage Beyond Toe East - None West - Seepage [illegible] East [illegible]

e. Abutments-Embankment Contact

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VISUAL INSPECTION CHECKLIST

1) Erosion at Contact East Dam - Erosion along [illegible] [illegible] along lower half of embankment. West Dam - Erosion along both Contacts

2) Seepage Along Contract East Dam - Wet areas observed in vicinity of Stone Gutters along west abutment lower ½ of embankment. West Dam - None

3) Drainage System

a. Description of System Internal Stone Underdrain shown on plans. Rock fill at toe of embankment. Foundation drain shown along Spillway [illegible].

b. Condition of System Not observable

c. Discharge from Drainage System None Observed. Minor Rust Colored Stained Water downstream of rock fill toe at both embankments

4) Instrumentation (Mo?mumentation/Surveys, Observation Wells, Weirs, Piezometers, Etc.)

NONE

VISUAL INSPECTION CHECKLIST

5) Reservoir

a. Slopes Moderate to Steep Slopes - Forested

b. Sedimentation Sedimentation has occurred, Turbidity of Reservoir Water quite high following Sept 1979 Flood

c. Unusual Conditions Which Affect Dam

6) Area Downstream of Dam

a. Downstream Hazard (No. of Homes, Highways, etc.) Few homes along [illegible] [illegible], Serious Flood Erosion of [illegible] due to [illegible]

b. Seepage, Unusual Growth Along [illegible] [illegible] Bedrock Outcrops

c. Evidence of Movement Beyond Toe of Dam None

d. Condition of Downstream Channel The water [illegible] [illegible] by Remains of Masonry Dam which was destroyed as part of this dam construction in 1937 ±

7) Spillway(s) (Including Discharge Conveyance Channel)

a. General Concrete Ogee Weir

b. Condition of Service Spillway Numerous [illegible] [illegible] [illegible] of Spillway [illegible] [illegible] [illegible] ≈ 6 inches, Erosion [illegible] 3' Deep by 4' wide by 8' Long, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] of [illegible] [illegible] [illegible] [illegible] 1" to 2". [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] ≈ 3' [illegible]

VISUAL INSPECTION CHECKLIST

c. Condition of Auxiliary Spillway Wooded Embankment on either side of spillway, grass covers on East Embankment crest, wooded on west embankment (See Survey Data of Spillway & East Embankment)

d. Condition of Discharge Conveyance Channel Good Some minor cracking along construction joints. Construction joints need to be refilled Note: Seepage emerging from embankment along west side of spillway ≈ at Elev. 1012 ±

8) Reservoir Drain/Outlet

Type: Pipe ✓ Conduit ____ Other ____

Material: Concrete ____ Metal ✓ Other ____

Size: ____ Length ____

Invert Elevations: Entrance [illegible] Exit [illegible]

Physical Condition (Describe): Unobservable ✓

Material: ____

Joints: ____ Alignment ____

Structural Integrity: ____

Hydraulic Capability: ____

Means of Control: Gate ____ Valve ✓ Uncontrolled ____

Operation: Operable ✓ Inoperable ____ Other ____

Present Condition (Describe): Operable & Closed Drain is a [illegible] [illegible] [illegible] [illegible] pipe to [illegible] [illegible]

No Operation & Maint. Records
No Warning System or Evacuation Plans
No Records on [illegible] [illegible] [illegible] [illegible]

9) Structural

a. Concrete Surfaces [illegible] - [illegible] [illegible]
Top of Conc. [illegible] - Badly Deteriorated

b. Structural Cracking Several Shrinkage Cracks in
Spillway Retaining Wall along Exit Channel

c. Movement - Horizontal & Vertical Alignment (Settlement)
Vertical - Ok
Horizontal - [illegible] Face [illegible]
[illegible]

d. Junctions with Abutments or Embankments Erosion [illegible]
Junction of embankment [illegible] East Wingwall of
Spillway

e. Drains - Foundation, Joint, Face [illegible]
along Wingwalls For Spillway.

f. Water Passages, Conduits, Sluices Concrete Pipe [illegible]

g. Seepage or Leakage Seepage [illegible] [illegible]
outside West Spillway Wingwall along
Embankment near elevation 1312.0

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h. Joints - Construction, etc. [illegible]
[illegible]

i. Foundation [illegible] Rock

j. Abutments N.A.

k. Control Gates N.A.

l. Approach & Outlet Channels [illegible]
approach channel and [illegible]

m. Energy Dissipators (Plunge Pool, etc.) [illegible]
From Outlet (Exit) Channel → Tributary

n. Intake Structures Unobservable

o. Stability Retaining (Wingwalls) Wall of Spillway
Questionable stability based on past movement

p. Miscellaneous Retaining Wall [illegible] in [illegible]
of Existing Bridge; Work to be completed in [illegible]

APPENDIX C

HYDROLOGIC/HYDRAULIC ENGINEERING DATA AND COMPUTATIONS

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CHECK LIST FOR DAMS
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

AREA-CAPACITY DATA:

	Elevation (ft.)	Surface Area (acres)	Storage Capacity (acre-ft.)
1) Top of Dam	[illegible]	[illegible]	[illegible]
2) Design High Water (Max.Design Pool)	[illegible]	58	[illegible]
3) Auxiliary Spillway Crest	N/A	N/A	N/A
4) Pool Level with Flashboards	N/A	N/A	N/A
5) Service Spillway Crest	[illegible]	~3	[illegible] (Est [illegible])

DISCHARGES

	Volume (cfs)
1) Average Daily	Unknown
2) Spillway @ Maximum High Water (Top of Dam)	3200
3) Spillway @ Design High Water (Top of Core [illegible])	4200
4) Spillway @ Auxiliary Spillway Crest Elevation	N/A
5) Low Level Outlet (Possible Drain)	
6) Total (of all facilities) @ Maximum High Water	
7) Maximum Known Flood	Unknown

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OUTLET STRUCTURES/EMERGENCY DRAWDOWN FACILITIES:

Type: Gate ✓ Sluice ____ Conduit ____ Penstock ____
Shape: Circular
Size: 12'
Elevations: Entrance Invert 1550
Exit Invert [illegible]
Tailrace Channel: Elevation ____

HYDROMETEROLOGICAL GAGES:

Type: ____
Location: Nearest Meterological Gage at Cornell Experiment Station Fredonia, New York
Records:
Date - ____
Max. Reading - ____

FLOOD WATER CONTROL SYSTEM:

Warning System: None

Method of Controlled Releases (mechanisms):

Reservoir Drain w/ Manually Operated Gate Valve
Valve at outlet of Tunnel under embankment

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CREST: ELEVATION: [illegible]

Type: [illegible]
Width: 110' Length: [illegible]
Spillover Concrete Ogee Weir
Location Between East & West Embankment

SPILLWAY:

PRINCIPAL		EMERGENCY
1036.0	Elevation	Varies to Elevation [illegible]
Concrete Ogee Weir	Type	Earth Cut (Natural Wall) [illegible]
75 feet	Width	Varies
	Type of Control	
✓	Uncontrolled	✓
	Controlled:	
	Type (Flashboards; gate)	
	Number	
	Size/Length	
	Invert Material	
	Anticipated Length of operating service	@ PMF - 7 hrs @ ½ PMF - 2.5 hrs
90 feet	Chute Length	11 feet (W [illegible]
4 feet	Height Between Spillway Crest & Approach Channel Invert (Weir Flow)	Varies

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DRAINAGE AREA: [illegible]

DRAINAGE BASIN RUNOFF CHARACTERISTICS:

Land Use - Type: Forested

Terrain - Relief: Moderate to Steep

Surface - Soil: Lacustrine Silt, Sand & Clay

Runoff Potential (existing or planned extensive alterations to existing surface or subsurface conditions)

No Changes Anticipated in Watershed

Potential Sedimentation problem areas (natural or man-made; present or future)

[illegible]
[illegible]
A problem.

Potential Backwater problem areas for levels at maximum storage capacity including surcharge storage:

None

Dikes - Floodwalls (overflow & non-overflow) - Low reaches along the Reservoir perimeter:

Location: None

Elevation:

[illegible]

[illegible]

[illegible]

$t_p =$ [illegible] $(L \cdot L_c)^2$ [illegible]

$=$ [illegible] $(\ldots \times 1.13)^2$ [illegible]

$= 2.22$ hr.

Check of [illegible]

[illegible]

[illegible]

$t_p =$ [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

6 hr. = [illegible]

12 hr. = [illegible]

24 hr. = 141[illegible]

SHEET NO. ____ OF ____
CALCULATED BY ____ DATE ____
CHECKED BY ____ DATE ____
SCALE ____

[illegible]

Elevation (Ft)	Area (Acres)	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	4[illegible]			5	[illegible]
		[illegible]	206		[illegible]
[illegible]	5[illegible]			206	[illegible]
		[illegible]	[illegible]		[illegible]
[illegible]	7[illegible]			[illegible]	

[illegible]

[illegible]

[illegible]

Acc[illegible]

1. [illegible]
2. [illegible]
3. [illegible]

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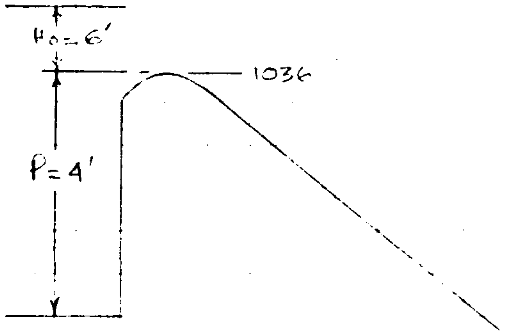
SHEET NO ______ OF ______
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______

[illegible]

Design head = H_o = 6'
Actual head = H_e

From Fig-249, PP. [illegible] of "Design of Small Dams"
P/H_o = 4/6 = 0.67 , C_o = 3.84



From Fig. 250 of "Design of Small Dams"

H_e @ 1' H_e/H_o = 1/6 = 0.17 C/C_o = 0.84 C = [illegible]

H_e @ 2' H_e/H_o = 2/6 = 0.33 C/C_o = 0.8[illegible] C = 0.8[illegible] × 3.8[illegible] = [illegible]

H_e @ 3' H_e/H_o = 3/6 = 0.5[illegible] C/C_o = 0.9[illegible] C = 0.9[illegible] × 3.8[illegible] = 3.[illegible]

H_e @ 4' H_e/H_o = 4/6 = 0.67 C/C_o = 0.9[illegible] C = [illegible] = 3.6[illegible]

H_e @ 5' H_e/H_o = 5/6 = 0.83 C/C_o = 0.9[illegible] C = 0.9[illegible] × 3.84 = 3.75

H_e @ 6' H_e/H_o = 6/6 = 1.0 C/C_o = 1.0 C = 1.0 × 3.84 = 3.84

H_e @ 7' H_e/H_o = 7/6 = 1.17 C/C_o = 1.02 C = 1.02 × 3.84 = 3.92

H_e @ 8' H_e/H_o = 8/6 = 1.33 C/C_o = 1.04 C = 1.04 × 3.[illegible] = 3.9[illegible]

H_e @ 9' H_e/H_o = 9/6 = 1.5 C/C_o = 1.06 C = 1.06 × 3.84 = 4.07

H_e @ 10' H_e/H_o = 10/6 = 1.67 C/C_o = 1.07 C = 1.07 × 3.84 = 4.10

H_e @ 11' H_e/H_o = 11/6 = 1.83 C/C_o = 1.07 C = 1.07 × 3.[illegible] = 4.1[illegible]

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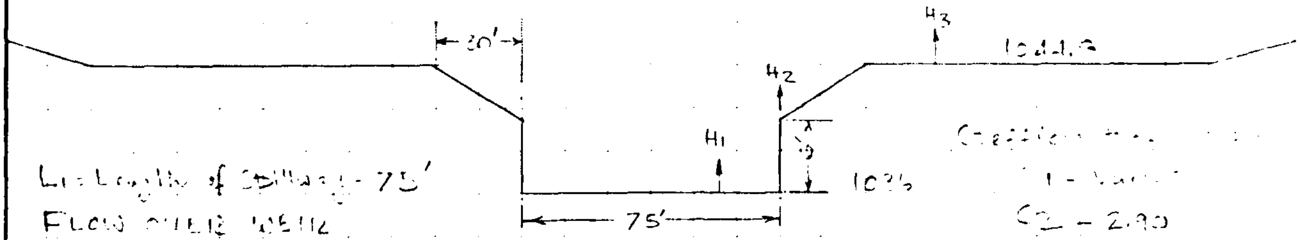
CALCULATED BY F[illegible] DATE
CHECKED BY DATE
SCALE

STAGE [illegible] COMPUTATIONS [illegible]



L = Length of Spillway - 75'
FLOW OVER WEIR
Q = CLH^{3/2}

Coefficients [illegible]
C1 - Varies
C2 - 2.90
C3 - 2.[illegible]

ELEV. (ft.)	H_1 (ft.)	$H_1^{3/2}$ (ft.)	C_1	H_2 (ft.)	$H_2^{3/2}$ (ft.)	L_2 (ft.)	H_3 (ft.)	H_3^{3} (ft.)	L_3 (ft.)	Q_1 (cfs)	Q_2 (cfs)	Q_3 (cfs)	TOTAL [illegible]
[illegible]36	0	0	–							0			0
[illegible]	1	1	3.2[illegible]							24[illegible]			2.41
[illegible]	2	2.83	3.4[illegible]							[illegible]			[illegible]
1039	3	5.2[illegible]	3.5[illegible]							13[illegible]			13[illegible]
[illegible]40	4	8.0	3.6[illegible]							2[illegible]			[illegible]
[illegible]41	5	11.1[illegible]	3.7[illegible]							31[illegible]			[illegible]
1042	6	14.7	3.8[illegible]							42[illegible]			4[illegible]
1043	7	18.[illegible]	3.92	1	1	13.33				54[illegible]	3[illegible]		5,4[illegible]
1044	8	22.62	3.9[illegible]	2	2.83	[illegible]				[illegible]	2[illegible]		[illegible]
[illegible]	9	27	4.07	3	5.2[illegible]	40.0	0.2	.089	670	83[illegible]	[illegible]	162	[illegible]
[illegible]	10	31.62	4.1[illegible]	4	[illegible]	[illegible]	1.2	1.314	670	[illegible]	[illegible]	[illegible]	1[illegible]
[illegible]	11	36.4[illegible]	4.1[illegible]	5	[illegible]	[illegible]	2.2	3.2[illegible]	670	11212	1,4[illegible]	[illegible]	[illegible]

PRODUCT 704-1 NEBS Inc. Groton, Mass. 01450

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[illegible]

Q	K'	[illegible]	[illegible]	S	[illegible]	[illegible]	[illegible]
241	[illegible]	[illegible]	[illegible]	4234	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2190	.0128	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3144	.0178	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	[illegible]

Note: The [illegible]

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[illegible]

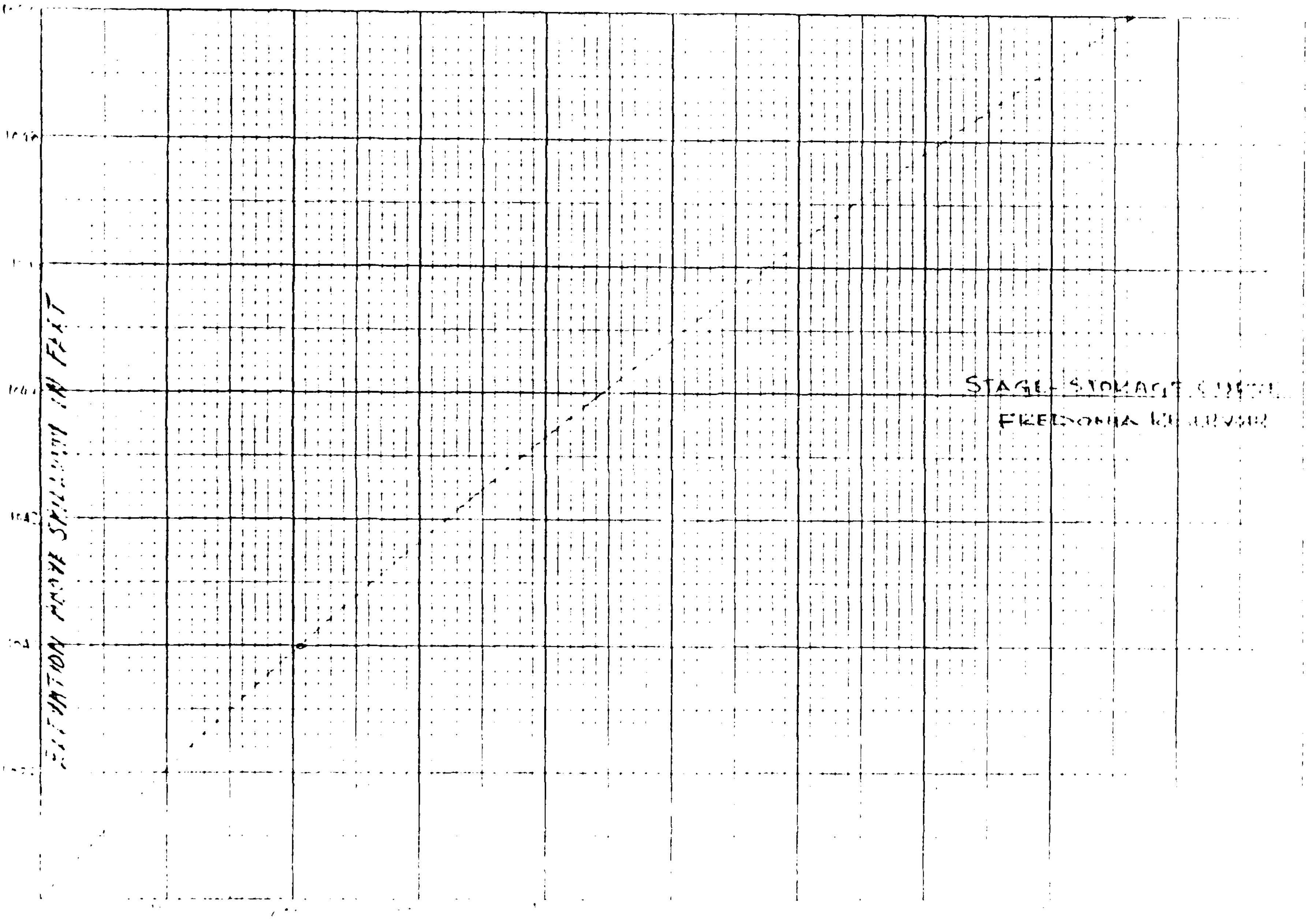
[illegible] King & Brater [illegible]

Elev.	H_1	H_2	H_2/H_1	[illegible]	[illegible]	C [illegible]	[illegible]
[illegible]	7	[illegible]	.034	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	8	[illegible]	.12	.041	[illegible]	[illegible]	[illegible]
1045	[illegible]	[illegible]	.20	[illegible]	[illegible]	[illegible]	[illegible]
1046	[illegible]	[illegible]	.33	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

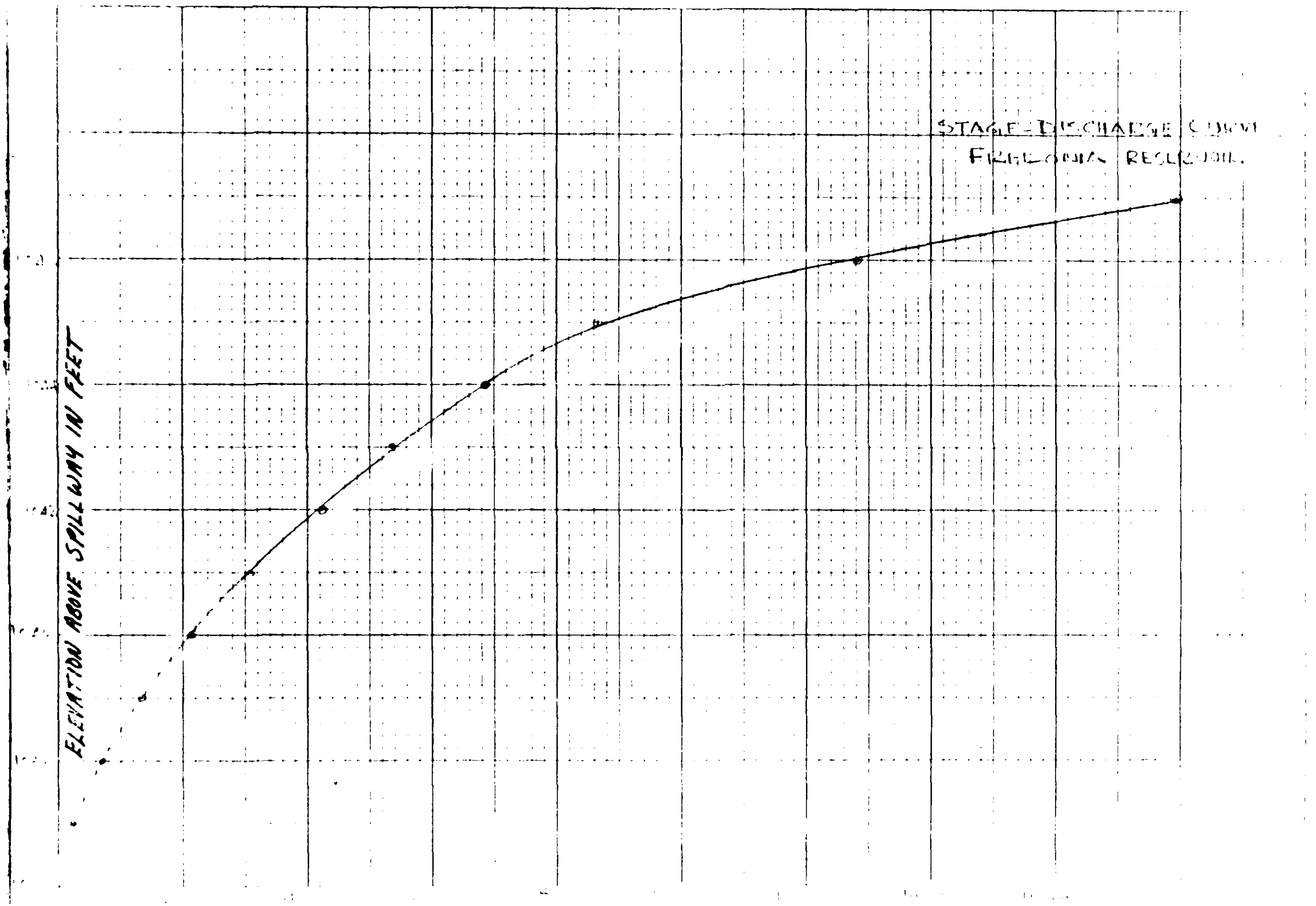
ELEVATION - STAGE - DISCHARGE DATA

Elev.	Discharge	Elev.	Discharge	Elev.	Discharge
[illegible]	0	[illegible]	[illegible]	1044	[illegible]
[illegible]	241	[illegible]	3144	[illegible]	[illegible]
[illegible]	722	1042	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1047	[illegible]

K&E 10 X 10 TO THE INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 0782



10 X 10 TO THE INCH
KEUFFEL & ESSER CO.
46 0782

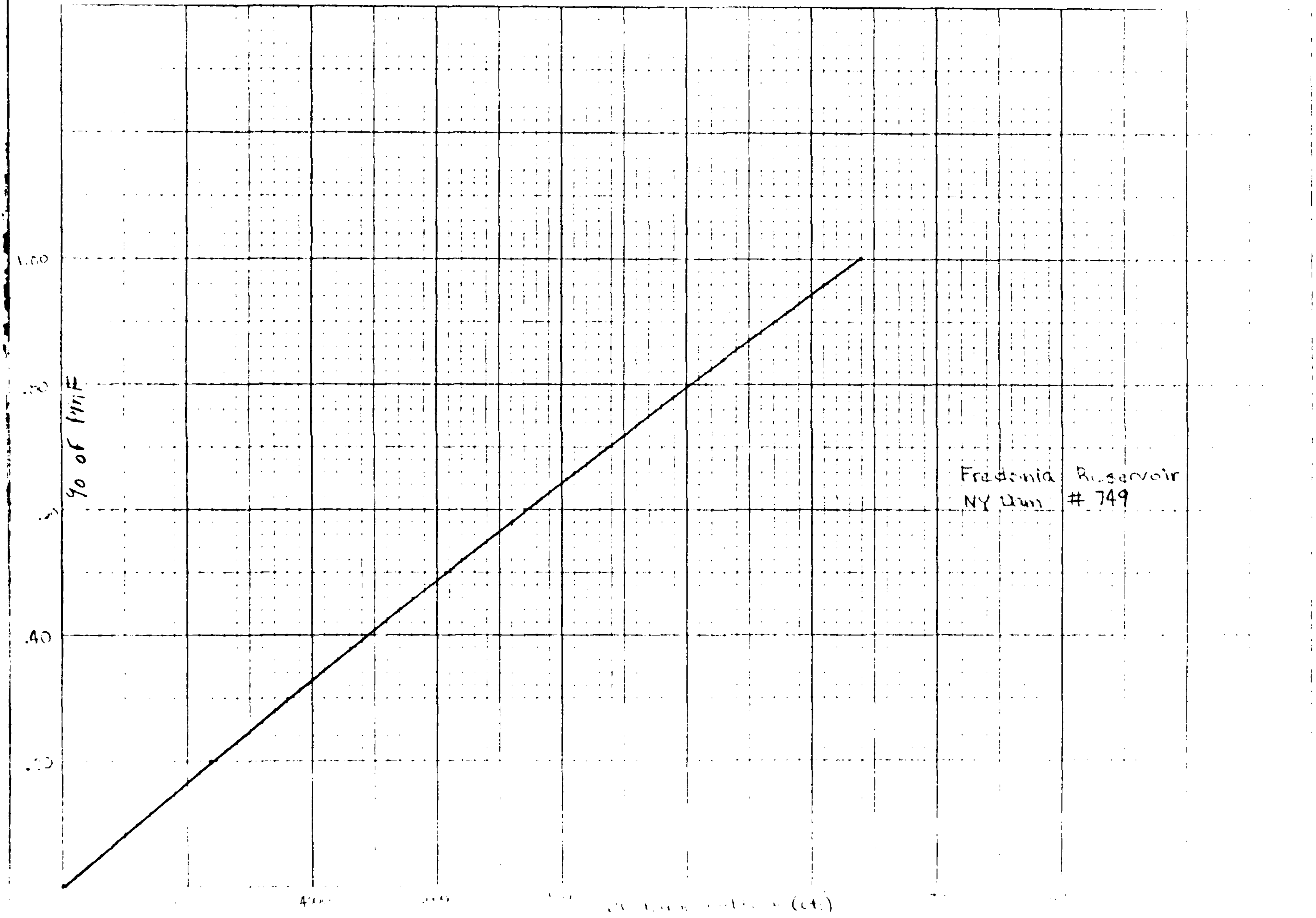


STAGE-DISCHARGE CURVE
FREDONIA RESERVOIR

El. 1036

K&E 10 X 10 TO THE INCH
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 0782



```
**************************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
 LAST MODIFICATION   26 FEB 79
**************************************
       1           A1              ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
       2           A2             HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF NY 749
       3           A3               RATIOS OF PMF ROUTED THROUGH THE RESERVOIR
       4           B     150         0        30         0         0         0         0         0         0         0
       5           B1      5
       6           J       1         5         1
       7           J1     .2       .35        .5       .65       .80         1
       8           K       0         1         0         0         0         0         1
       9           K1        CALCULATION OF INFLOW HYDROGRAPH
      10           M       1         1      5.55         0      5.55         0         0         0         0         0
      11           P       0      22.7       115       127       141         0         0         0         0         0
      12           T       0         0         0         0         0         0         1        .1         0         0
      13           W    2.52       .65
      14           X      -2       -.1         2
      15           K       1         2         0         0         0         0         1         0         0         0
      16           K1        ROUTING OF INFLOW HYDROGRAPH
      17           Y       0         0         0         1         1
      18           Y1      1         0         0         0         0         0     -1036        -1
      19           Y4   1036      1037      1038      1039      1040      1041      1042      1043      1044      1045
      20           Y4   1046      1047
      21           Y5      0       241       722      1377      2190      3144      4234      5457      6648      8491
      22           Y5  10405     12044
      23           $S      0        43        98       150       206       262       321       381       445       510
      24           $S    575       643
      25           $E   1036      1037      1038      1039      1040      1041      1042      1043      1044      1045
      26           $E   1046      1047
      27           $$   1036
      28           $D1044.5       2.7       1.5       670
      29           K      99
```

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**********************************
[illegible]
[illegible]
[illegible]
**********************************

     [illegible]

                         ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
                        HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF NY 749
                         RATIOS OF PMF ROUTED THROUGH THE RESERVOIR

                                      JOB SPECIFICATION
            NQ       NHR      NMIN      IDAY       IHR      IMIN     METRC      IPLT      IPRT     NSTAN
           150         0        30         0         0         0         0         0         0         0
                                         JOPER       NWT     LROPT     TRACE
                                             5         0         0         0

                              MULTI-PLAN ANALYSES TO BE PERFORMED
                                  NPLAN= 1 NRTIO= 6 LRTIO= 1
                RTIOS=    0.20     0.35     0.50     0.65     0.80     1.00


      **********          **********          **********          **********          **********

                                 SUB-AREA RUNOFF COMPUTATION

                 CALCULATION OF INFLOW HYDROGRAPH

                              ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE    IAUTO
                                  1        0        0        0        0        0        1        0        0

                                         HYDROGRAPH DATA
                 IHYDG     IUHG    TAREA     SNAP    TRSDA    TRSPC    RATIO    ISNOW    ISAME    LOCAL
                     1        1     5.55     0.00     5.55     0.00    0.000        0        0        0

                                           PRECIP DATA
                        SPFE      PMS       R6      R12      R24      R48      R72      R96
                        0.00    22.70   115.00   127.00   141.00     0.00     0.00     0.00
TRSPC COMPUTED BY THE PROGRAM IS 0.800

                                            LOSS DATA
           LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
               0    0.00    0.00    1.00    0.00    0.00    1.00    1.00    0.10    0.00    0.00

                                      UNIT HYDROGRAPH DATA
                                   TP=  2.62     CP=0.63     NTA=  0

                                          RECESSION DATA
                           STRTQ=    -2.00     QRCSN=    -0.10     RTIOR= 2.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 6.20 AND R= 4.65 INTERVALS

                UNIT HYDROGRAPH 28 END-OF-PERIOD ORDINATES, LAG=   2.62 HOURS, CP= 0.63  VOL= 1.00
           54.       231.       454.       673.       822.       865.       780.       635.       511.       412.
          332.       268.       216.       174.       140.       113.        91.        73.        59.        48.
           38.        31.        25.        20.        16.        13.        11.         8.

                                      END-OF-PERIOD FLOW
```

```
MO.DA  HR.MN  PERIOD  RAIN         EXCS         LOSS         COMP Q      MO.DA  HR.MN  PERIOD  RAIN  EXCS  LOSS  COMP Q
 1.01   0.30     1    [illegible]  [illegible]  [illegible]      1.       1.02  14.00    76    0.00  0.00  0.00   234.
 1.01   1.00     2    [illegible]  [illegible]  [illegible]      1.       1.02  14.30    77    0.00  0.00  0.00   218.
 1.01   1.30     3    [illegible]  [illegible]  [illegible]      4.       1.02  15.00    78    0.00  0.00  0.00   203.
 1.01   2.00     4    [illegible]  [illegible]  [illegible]      5.       1.02  15.30    79    0.00  0.00  0.00   190.
 1.01   2.30     5    [illegible]  [illegible]  [illegible]      5.       1.02  16.00    80    0.00  0.00  0.00   177.
 1.01   3.00     6    [illegible]  [illegible]  [illegible]      7.       1.02  16.30    81    0.00  0.00  0.00   165.
 1.01   3.30     7    [illegible]  [illegible]  [illegible]      7.       1.02  17.00    82    0.00  0.00  0.00   154.
 1.01   4.00     8    [illegible]  [illegible]  [illegible]      8.       1.02  17.30    83    0.00  0.00  0.00   144.
 1.01   4.30     9    [illegible]  [illegible]  0.05             8.       1.02  18.00    84    0.00  0.00  0.00   134.
 1.01   5.00    10    [illegible]  [illegible]  [illegible]      6.       1.02  18.30    85    0.00  0.00  0.00   125.
 1.01   5.30    11    0.08         [illegible]  [illegible]      5.       1.02  19.00    86    0.00  0.00  0.00   117.
 1.01   6.00    12    [illegible]  [illegible]  [illegible]      5.       1.02  19.30    87    0.00  0.00  0.00   109.
 1.01   6.30    13    0.17         0.12         0.05            14.       1.02  20.00    88    0.00  0.00  0.00   102.
 1.01   7.00    14    0.17         0.12         0.05            42.       1.02  20.30    89    0.00  0.00  0.00    95.
 1.01   7.30    15    0.17         0.12         0.05            96.       1.02  21.00    90    0.00  0.00  0.00    89.
 1.01   8.00    16    0.17         0.12         0.05           175.       1.02  21.30    91    0.00  0.00  0.00    83.
 1.01   8.30    17    0.17         0.12         0.05           271.       1.02  22.00    92    0.00  0.00  0.00    77.
 1.01   9.00    18    0.17         0.12         0.05           371.       1.02  22.30    93    0.00  0.00  0.00    72.
 1.01   9.30    19    0.17         0.12         0.05           458.       1.02  23.00    94    0.00  0.00  0.00    67.
 1.01  10.00    20    0.17         0.12         0.05           533.       1.02  23.30    95    0.00  0.00  0.00    63.
 1.01  10.30    21    0.17         0.12         0.05           592.       1.03   0.00    96    0.00  0.00  0.00    58.
 1.01  11.00    22    0.17         0.12         0.05           639.       1.03   0.30    97    0.00  0.00  0.00    54.
 1.01  11.30    23    0.17         0.12         0.05           677.       1.03   1.00    98    0.00  0.00  0.00    51.
 1.01  12.00    24    0.17         0.12         0.05           708.       1.03   1.30    99    0.00  0.00  0.00    47.
 1.01  12.30    25    1.08         1.03         0.05           749.       1.03   2.00   100    0.00  0.00  0.00    44.
 1.01  13.00    26    1.05         1.00         0.05          1014.       1.03   2.30   101    0.00  0.00  0.00    41.
 1.01  13.30    27    1.26         1.21         0.05          1446.       1.03   3.00   102    0.00  0.00  0.00    39.
 1.01  14.00    28    1.26         1.21         0.05          2104.       1.03   3.30   103    0.00  0.00  0.00    36.
 1.01  14.30    29    1.58         1.53         0.05          2959.       1.03   4.00   104    0.00  0.00  0.00    34.
 1.01  15.00    30    1.58         1.53         0.05          3949.       1.03   4.30   105    0.00  0.00  0.00    31.
 1.01  15.30    31    1.92         1.87         0.05          4986.       1.03   5.00   106    0.00  0.00  0.00    29.
 1.01  16.00    32    5.78         5.73         0.05          6293.       1.03   5.30   107    0.00  0.00  0.00    27.
 1.01  16.30    33    1.47         1.42         0.05          7999.       1.03   6.00   108    0.00  0.00  0.00    25.
 1.01  17.00    34    1.47         1.42         0.05          9526.       1.03   6.30   109    0.00  0.00  0.00    24.
 1.01  17.30    35    1.16         1.11         0.05         11448.       1.03   7.00   110    0.00  0.00  0.00    22.
 1.01  18.00    36    1.16         1.11         0.05         12520.       1.03   7.30   111    0.00  0.00  0.00    21.
 1.01  18.30    37    0.13         0.08         0.05         12511.       1.03   8.00   112    0.00  0.00  0.00    19.
 1.01  19.00    38    0.13         0.08         0.05         12132.       1.03   8.30   113    0.00  0.00  0.00    18.
 1.01  19.30    39    0.13         0.08         0.05         10949.       1.03   9.00   114    0.00  0.00  0.00    17.
 1.01  20.00    40    0.13         0.08         0.05          9549.       1.03   9.30   115    0.00  0.00  0.00    16.
 1.01  20.30    41    0.13         0.08         0.05          8195.       1.03  10.00   116    0.00  0.00  0.00    15.
 1.01  21.00    42    0.13         0.08         0.05          6731.       1.03  10.30   117    0.00  0.00  0.00    14.
 1.01  21.30    43    0.13         0.08         0.05          5537.       1.03  11.00   118    0.00  0.00  0.00    13.
 1.01  22.00    44    0.13         0.08         0.05          4573.       1.03  11.30   119    0.00  0.00  0.00    12.
 1.01  22.30    45    0.13         0.08         0.05          3790.       1.03  12.00   120    0.00  0.00  0.00    11.
 1.01  23.00    46    0.13         0.08         0.05          3161.       1.03  12.30   121    0.00  0.00  0.00    10.
 1.01  23.30    47    0.13         0.08         0.05          2654.       1.03  13.00   122    0.00  0.00  0.00    10.
 1.02   0.00    48    0.13         0.08         0.05          2246.       1.03  13.30   123    0.00  0.00  0.00     9.
 1.02   0.30    49    0.10         [illegible]  0.00          1811.       1.03  14.00   124    0.00  0.00  0.00     8.
 1.02   1.00    50    0.00         0.00         0.00          1628.       1.03  14.30   125    0.00  0.00  0.00     8.
 1.02   1.30    51    0.00         0.00         0.00          1379.       1.03  15.00   126    0.00  0.00  0.00     7.
 1.02   2.00    52    0.00         0.00         0.00          1233.       1.03  15.30   127    0.00  0.00  0.00     7.
 1.02   2.30    53    0.00         0.00         0.00          1150.       1.03  16.00   128    0.00  0.00  0.00     6.
 1.02   3.00    54    0.00         0.00         0.00          1073.       1.03  16.30   129    0.00  0.00  0.00     6.
 1.02   3.30    55    0.00         0.00         0.00          1001.       1.03  17.00   130    0.00  0.00  0.00     6.
 1.02   4.00    56    0.00         0.00         0.00           934.       1.03  17.30   131    0.00  0.00  0.00     5.
 1.02   4.30    57    0.00         0.00         0.00           872.       1.03  18.00   132    0.00  0.00  0.00     5.
 1.02   5.00    58    0.00         0.00         0.00           813.       1.03  18.30   133    0.00  0.00  0.00     4.
 1.02   5.30    59    0.00         0.00         0.00           759.       1.03  19.00   134    0.00  0.00  0.00     4.
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[illegible]   1.03  [illegible]   135  [illegible]  [illegible]  [illegible]        4.
[illegible]   1.03  [illegible]   136  [illegible]  [illegible]  [illegible]        4.
[illegible]   1.03  2[illegible].30  137   0.00   0.00   0.00        3.
[illegible]   1.03  21.00   138   0.00   0.00   0.00        3.
[illegible]   1.03  21.30   139   0.00   0.00   0.00        3.
[illegible]   1.03  22.00   140   0.00   0.00   0.00        3.
[illegible]   1.03  22.30   141   0.00   0.00   0.00        3.
[illegible]   1.03  23.00   142   0.00   0.00   0.00        2.
[illegible]   1.03  23.30   143   0.00   0.00   0.00        2.
[illegible]   1.04   0.00   144   0.00   0.00   0.00        2.
[illegible]   1.04   0.30   145   0.00   0.00   0.00        2.
[illegible]   1.04   1.00   146   0.00   0.00   0.00        2.
[illegible]   1.04   1.30   147   0.00   0.00   0.00        2.
[illegible]   1.04   2.00   148   0.00   0.00   0.00        2.
[illegible]   1.04   2.30   149   0.00   0.00   0.00        1.
[illegible]   1.04   3.00   150   0.00   0.00   0.00        1.

                              SUM  25.51  22.80   2.81   175591.
                                 ( 65[illegible].)( 579.)(  71.)( 4972.18)

                  PEAK    5-HOUR   24-HOUR   72-HOUR   TOTAL VOLUME
         CFS     12411.    4473.     3501.     1219.       175585.
         CMS       353.     253.       99.       35.         4972.
      INCHES               15.44     23.17     24.52         24.52
          MM              393.23    588.14    622.8[illegible]        622.83
       AC-FT               4437.     6944.     7255.         7255.
  THOUS CU M               5744.     8565.     8949.         8950.


                HYDROGRAPH AT STA [illegible]    FOR PLAN 1, RTIO 1
   2.      2.      2.      2.      2.      1.      1.      1.      1.      1.
   1.      1.      3.      6.     14.     31.     54.     74.     92.    107.
[illegible] 12[illegible]. 13[illegible].    142.  15[illegible].  2[illegible]3.  2[illegible].  4[illegible]1.    592.    790.
[illegible] [illegible] [illegible]  1405.  22[illegible].  25[illegible].   2562.   2436.   2190.   1910.
1[illegible]. 1[illegible]. 11[illegible]7.    914.  75[illegible].    632.    531.    449.    362.    326.
27[illegible].    247.  23[illegible].    215.  2[illegible].    167.    174.    153.    152.    142.
1[illegible]2.    113.  11[illegible].  1[illegible]7.  1[illegible].   4[illegible].     87.     81.     76.     71.
[illegible]   [illegible]2.   5[illegible].     54.   5[illegible].   4[illegible].     44.     41.     38.     35.
  33.     31.     29.     27.     25.     23.     22.     20.     19.     18.
  17.     15.     14.     13.     13.     12.     11.     10.      9.      8.
[illegible]  [illegible]     7.      7.      6.      6.      5.      5.      5.      4.
   4.  [illegible] [illegible]     3.      3.      3.      3.      3.      2.      2.
   2.      2.      2.      2.      2.      1.      1.      1.      1.      1.
   1.      1.      1.      1.      1.      1.      1.      1.      1.      1.
   1.      0.      0.      0.      0.      0.      0.      0.      0.      0.

                  PEAK    5-HOUR   24-HOUR   72-HOUR   TOTAL VOLUME
         CFS      2[illegible]2.    1493.      760.      249.        35117.
         CMS        73.      54.      2[illegible].        7.          994.
      INCHES                3.15      4.69      4.90          4.90
          MM               80.0[illegible]    119.23    124.58        124.59
       AC-FT                934.     1394.     1451.         1451.
  THOUS CU M               1152.     1719.     1790.         1790.


                HYDROGRAPH AT STA [illegible]    FOR PLAN 1, RTIO 2
[illegible] [illegible]      3.      3.      3.      3.      2.      2.      2.      2.
   2.  [illegible]  [illegible]    13.   3[illegible].     61.     95.    130.    161.    197.
[illegible] [illegible] 2[illegible]. 2[illegible]. 2[illegible].  35[illegible].  5[illegible].    735.   1035.   1382.
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 [illegible]  [illegible]  [illegible]  [illegible]  [illegible]  [illegible]  [illegible]    4264.    3532.    3342.
 [illegible]  [illegible]  [illegible]  [illegible]  [illegible]  [illegible]     924.      756.     659.     570.
 [illegible]  [illegible]  [illegible]  [illegible]  [illegible]     327.        305.      285.     256.     245.
    231.     [illegible]  [illegible]  [illegible]     175.         164.        153.      142.     133.     124.
 [illegible]  [illegible]  [illegible]      94.         88.          82.         76.       71.      66.      62.
 [illegible]  [illegible]  [illegible]      47.         44.          41.         38.       36.      33.      31.
 [illegible]      27.      [illegible]      23.         22.          20.         19.       18.      17.      15.
     14.          13.          13.          12.         11.          10.         10.        9.       8.       8.
 [illegible]       7.           6.           6.          5.           5.          5.        4.       4.       4.
      4.           3.           3.           3.          3.           3.          2.        2.       2.       2.
      2.           2.           2.           1.          1.           1.          1.        1.       1.       1.
      1.           1.           1.           1.          1.           1.          1.        1.       1.       0.

                     PEAK    6-HOUR    24-HOUR    72-HOUR    TOTAL VOLUME
           CFS      4451.    3316.     1225.       427.          61455.
           CMS       126.      94.       35.        12.           1740.
        INCHES               5.56      8.21       8.56            8.56
            MM             141.15    208.55     218.01          218.02
         AC-FT              1644.     2431.      2539.           2539.
    THOUS CU M              2028.     2998.      3132.           3132.


                    HYDROGRAPH AT STA      1 FOR PLAN 1, RTIO 3
      5.           5.           5.           4.          4.           4.          3.        3.       3.       3.
      3.           3.           7.          21.     [illegible]      87.        135.      185.     230.     267.
 [illegible]  [illegible]  [illegible]  [illegible]  [illegible]     567.        723.     1052.    1480.    1975.
 [illegible]  [illegible]  [illegible]    4413.       5721.     [illegible]     6405.     6091.    5475.    4775.
 [illegible]  [illegible]  [illegible]  [illegible]  [illegible]  [illegible]   1327.     1123.     956.     814.
 [illegible]  [illegible]     575.         537.     [illegible]     467.        436.      407.     379.     354.
 [illegible]  [illegible]  [illegible]  [illegible]  [illegible]     234.        218.      203.     190.     177.
 [illegible]  [illegible]  [illegible]  [illegible]     125.         117.        109.      102.      95.      89.
     83.          77.          72.          67.         63.      [illegible]      54.       51.      47.      44.
     41.      [illegible]  [illegible]      34.         31.          29.         27.       25.      24.      22.
     21.      [illegible]  [illegible]      17.         16.          15.         14.       13.      12.      11.
 [illegible]      10.      [illegible]  [illegible]  [illegible]      7.          7.        6.       6.       6.
      5.      [illegible]       4.           4.          4.           4.          3.        3.       3.       3.
      3.           2.           2.           2.          2.           2.          2.        2.       1.       1.
      1.           1.           1.           1.          1.           1.          1.        1.       1.       1.

                     PEAK    6-HOUR    24-HOUR    72-HOUR    TOTAL VOLUME
           CFS      6405.    4736.     1750.       610.          87792.
           CMS       181.     134.       50.        17.           2486.
        INCHES               7.94     11.74      12.26           12.26
            MM             201.54    293.07     311.45          311.46
         AC-FT              2349.     3472.      3628.           3628.
    THOUS CU M              2897.     4282.      4475.           4475.


                    HYDROGRAPH AT STA      1 FOR PLAN 1, RTIO 4
      7.           6.           6.           5.          5.           5.          4.        4.       4.       4.
      3.           3.           9.          27.         62.         114.        176.      241.     299.     347.
 [illegible]  [illegible]  [illegible]  [illegible]     515.     [illegible]     940.     1367.    1923.    2567.
 [illegible]  [illegible]  [illegible]  [illegible]    7441.     [illegible]    8327.     7916.    7117.    6207.
 [illegible]  [illegible]  [illegible]  [illegible]  [illegible]  [illegible]   1725.     1460.    1242.    1058.
 [illegible]  [illegible]  [illegible]  [illegible]     651.         607.        567.      529.     493.     460.
 [illegible]  [illegible]  [illegible]  [illegible]     325.     [illegible]     283.      264.     247.     230.
    215.      [illegible]     187.         174.        163.         152.        142.      132.     123.     115.
    107.      [illegible]  [illegible]      87.         81.          76.         71.       66.      62.      58.
 [illegible]  [illegible]      47.      [illegible]     41.          38.         35.       33.      31.      29.
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    27.       2[illegible].       25.       22.       2[illegible].       19.       18.       17.       15.       14.
    13.       1[illegible].       1[illegible].       11.       10.        9.        9.        8.        8.        7.
     7.        [illegible]        [illegible]        5.        5.        5.        4.        4.        4.        4.
     3.        3.        3.        3.        3.        2.        2.        2.        2.        2.
     2.        2.        1.        1.        1.        1.        1.        1.        1.        1.

                    PEAK      6-HOUR    24-HOUR    72-HOUR   TOTAL VOLUME
         CFS        9327.      6157.      2275.       793.      114130.
         CMS         264.       174.        64.        22.        3232.
      INCHES                   10.32      15.26      15.94        15.94
          MM                  262.14     387.49     404.85       404.90
       AC-FT                   3055.      4513.      4716.        4716.
  THOUS CU M                   3768.      5567.      5817.        5817.


                    HYDROGRAPH AT STA      1 FOR PLAN 1, RTIO 5
     8.        8.        7.        7.        6.        6.        5.        5.        5.        4.
     8.        [illegible]       11.       33.       77.      140.      217.      296.      358.      426.
   473.      511.      542.      560.      631.      811.     1157.     1663.     2367.     3159.
  3359.     5634.     5395.     7661.     9156.    10016.    10249.     9745.     8759.     7640.
  8404.     5535.     4430.     3555.     3032.     2529.     2123.     1796.     1529.     1303.
  1103.      955.      820.      559.      501.      747.      697.      651.      607.      566.
   529.      493.      466.      449.      431.      374.      349.      325.      304.      283.
   264.      247.      231.      215.      200.      187.      174.      163.      152.      142.
   132.      123.      115.      107.      100.       93.       87.       81.       76.       71.
    66.       62.       58.       54.       50.       47.       44.       41.       38.       35.
    33.       31.       29.       27.       25.       23.       22.       20.       19.       18.
    17.       15.       14.       13.       13.       12.       11.       10.        9.        9.
     9.        8.        7.        7.        6.        6.        5.        5.        5.        4.
     4.        4.        4.        3.        3.        3.        3.        3.        2.        2.
     2.        2.        2.        2.        2.        1.        1.        1.        1.        1.

                    PEAK      6-HOUR    24-HOUR    72-HOUR   TOTAL VOLUME
         CFS       10243.      7578.      2801.       975.      140468.
         CMS         290.       215.        79.        28.        3978.
      INCHES                   12.70      18.75      19.52        19.62
          MM                  322.63     476.91     495.32       496.34
       AC-FT                   3755.      5555.      5804.        5804.
  THOUS CU M                   4635.      6852.      7159.        7160.


                    HYDROGRAPH AT STA      1 FOR PLAN 1, RTIO 6
    10.       10.        9.        9.        9.        7.        7.        6.        6.        6.
     5.        5.       14.       42.       96.      175.      271.      371.      460.      533.
   552.      633.      677.      764.      799.     1014.     1446.     2104.     2959.     3949.
  4966.     6293.     7449.     9826.    11443.    12520.    12811.    12152.    10949.     9549.
  8109.     6751.     5537.     4570.     3739.     3161.     2654.     2246.     1911.     1628.
  1374.     1233.     1155.     1075.     1001.      934.      872.      813.      759.      708.
   661.      617.      575.      537.      501.      467.      436.      407.      379.      354.
   330.      308.      288.      268.      250.      234.      218.      203.      190.      177.
   165.      154.      144.      134.      125.      117.      109.      102.       95.       89.
    83.       77.       72.       67.       63.       58.       54.       51.       47.       44.
    41.       39.       36.       34.       31.       29.       27.       25.       24.       22.
    21.       19.       18.       17.       16.       15.       14.       13.       12.       11.
    10.       10.        9.        8.        8.        7.        7.        6.        6.        6.
     5.        5.        4.        4.        4.        4.        3.        3.        3.        3.
     3.        2.        2.        2.        2.        2.        2.        2.        1.        1.

                    PEAK      6-HOUR    24-HOUR    72-HOUR   TOTAL VOLUME
          [illegible]  [illegible]  [illegible]      [illegible] 1.     1219.        175555.
          [illegible]  [illegible]  [illegible]      [illegible]         35.          4972.
          [illegible]               [illegible]      23.47        24.32         24.32
                                    [illegible]      [illegible]  522.90        622.93
          [illegible]               [illegible]      [illegible]  7255.         7256.
          [illegible]               [illegible]      [illegible]  8949.         8950.


 **********          **********          **********          **********          **********

                                  HYDROGRAPH ROUTING

              ROUTING OF INFLOW HYDROGRAPH

                    ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                        2       1       0       0       0       0       1       0       0
                                        ROUTING DATA
              QLOSS   CLOSS     AVG    IRES   ISAME    IOPT    IPMP            LSTR
                0.0   0.000    0.00       1       1       0       0               0

                    NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA  ISPRAT
                        1       0       0   0.000   0.000   0.000  -1036.      -1

STAGE      1036.00    1037.00    1038.00    1039.00    1040.00    1041.00    1042.00    1043.00    1044.00
           1045.00    1047.00

FLOW          0.00     241.00     722.00    1377.00    2190.00    3144.00    4231.00    5457.00    6848.00
          17456.00   12544.00

CAPACITY=        0.        46.        95.       150.       206.       262.       321.       381.       445.       510.
               575.       643.

ELEVATION=    1036.      1037.      1038.      1039.      1040.      1041.      1042.      1043.      1044.      1045.
              1045.      1047.

                     CREL   SPWID    COQW    EXPW   ELEVL    COQL   CAREA    EXPL
                   1036.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

                                        DAM DATA
                                   TOPEL    COQD    EXPD  DAMWID
                                  1044.6     2.7     1.5    670.

                              STATION      2, PLAN 1, RATIO 1

                             END-OF-PERIOD HYDROGRAPH ORDINATES

                                          OUTFLOW
        0.        1.        1.        1.        1.        1.        1.        1.        1.        1.
        1.        1.        1.        2.        4.        9.       15.       25.       36.       48.
       66.       72.       83.       93.      104.      116.      142.      182.      245.      393.
      559.      754.     1033.     1342.     1701.     2022.     2267.     2388.     2349.     2193.
     1945.     1739.     1514.     1292.     1103.      935.      789.      677.      590.      512.
      442.      382.      334.      297.      267.      243.      231.      219.      208.      196.
      185.      174.      164.      154.      145.      136.      127.      119.      112.      104.
       96.       91.       85.       80.       75.       70.       65.       61.       57.       53.
       49.       46.       43.       40.       38.       35.       33.       31.       28.       27.
       25.       23.       22.       20.       18.       17.       16.       15.       14.       13.
       12.       12.       11.       10.        9.        9.        8.        8.        7.        7.
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        5.          5.          5.          5.          4.          4.          4.          4.          4.          3.
        3.          3.          3.          3.          2.          2.          2.          2.          2.          2.
        2.          1.          1.          1.          1.          1.          1.          1.          1.          1.
        1.          1.          1.          1.          1.          1.          1.          1.          0.          0.

                                                            STORAGE
        0.          0.          0.          0.          0.          0.          0.          0.          0.          0.
        0.          0.          0.          0.          1.          2.          3.          5.          7.          9.
       12.         14.         17.         19.         21.         24.         26.         30.         46.         64.
       81.        101.        125.        147.        172.        194.        210.        218.        215.        206.
      193.        175.        155.        143.        126.        115.        103.         93.         84.         76.
       69.         63.         58.         54.         51.         48.         46.         44.         41.         39.
       37.         35.         33.         31.         29.         27.         25.         24.         22.         21.
       19.         18.         17.         16.         15.         14.         13.         12.         11.         11.
       10.          9.          8.          8.          7.          7.          7.          6.          6.          5.
        5.          5.          4.          4.          4.          3.          3.          3.          3.          3.
        2.          2.          2.          2.          2.          2.          2.          2.          1.          1.
        1.          1.          1.          1.          1.          1.          1.          1.          1.          1.
        1.          1.          1.          0.          0.          0.          0.          0.          0.          0.
        0.          0.          0.          0.          0.          0.          0.          0.          0.          0.
        0.          0.          0.          0.          0.          0.          0.          0.          0.          0.

                                                              STAGE
   1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0
   1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.1      1036.1      1036.1      1036.2
   1036.2      1036.3      1036.3      1036.4      1036.4      1036.5      1036.6      1036.8      1037.0      1037.3
   1037.7      1038.0      1038.5      1038.9      1039.3      1039.8      1040.1      1040.2      1040.2      1040.0
   1039.8      1039.5      1039.2      1038.9      1038.6      1038.3      1038.1      1037.9      1037.7      1037.6
   1037.4      1037.3      1037.2      1037.1      1037.1      1037.0      1037.0      1036.9      1036.9      1036.8
   1036.7      1036.7      1036.7      1036.6      1036.6      1036.6      1036.5      1036.5      1036.5      1036.4
   1036.4      1036.4      1036.3      1036.3      1036.3      1036.3      1036.3      1036.3      1036.2      1036.2
   1036.2      1036.2      1036.2      1036.2      1036.2      1036.1      1036.1      1036.1      1036.1      1036.1
   1036.1      1036.1      1036.1      1036.1      1036.1      1036.1      1036.1      1036.1      1036.1      1036.1
   1036.1      1036.1      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0
   1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0
   1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0
   1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0
   1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0

PEAK OUTFLOW IS      2365. AT TIME  19.00 HOURS


                                PEAK     6-HOUR    24-HOUR    72-HOUR    TOTAL VOLUME
                        CFS    2365.      1824.       696.       244.          35123.
                        CMS      67.        52.        20.         7.            995.
                     INCHES                3.05       4.55       4.91            4.91
                         MM               77.58     115.44     124.60          124.61
                      AC-FT                904.      1380.      1451.           1451.
                 THOUS CU M               1115.      1702.      1790.           1790.


                                           STATION      2, PLAN 1, RATIO 2

                                        END-OF-PERIOD HYDROGRAPH ORDINATES

                                                     OUTFLOW
        1.          1.          2.          2.          2.          2.          2.          2.          2.          2.
        2.          2.          2.          4.          8.         15.         27.         43.         62.         83.
      104.        123.        142.        163.        182.        207.        255.        376.        545.        776.
     1161.       1472.       1947.       2526.       3150.       3727.       4117.       4261.       4141.       3835.
   3624.      2977.      2535.      2146.      1851.      1547.      1311.      1123.       953.       819.
    705.       621.       544.       493.       454.       417.       363.       354.       325.       304.
    265.       253.       243.       234.       224.       214.       204.       193.       183.       173.
    163.       153.       144.       135.       127.       119.       112.       104.        98.        91.
     86.        80.        75.        70.        65.        61.        57.        53.        50.        46.
     43.        40.        37.        35.        33.        31.        29.        27.        25.        23.
     22.        20.        19.        17.        16.        15.        14.        13.        12.        12.
     11.        10.         9.         9.         8.         8.         7.         7.         6.         6.
      5.         5.         5.         4.         4.         4.         4.         3.         3.         3.
      3.         3.         2.         2.         2.         2.         2.         2.         2.         1.
      1.         1.         1.         1.         1.         1.         1.         1.         1.         1.

                                                  STORAGE
      0.         0.         0.         0.         0.         0.         0.         0.         0.         0.
      0.         0.         0.         1.         1.         3.         5.         9.        12.        17.
     21.        25.        29.        33.        38.        41.        49.        62.        80.       102.
    128.       157.       194.       220.       262.       294.       315.       322.       316.       299.
    277.       252.       227.       203.       181.       162.       145.       130.       117.       106.
     96.        86.        81.        75.        70.        66.        63.        60.        57.        55.
     52.        50.        49.        47.        45.        43.        41.        38.        36.        34.
     32.        31.        29.        27.        25.        24.        22.        21.        19.        18.
     17.        16.        15.        14.        13.        12.        11.        11.        10.         9.
      8.         8.         8.         7.         7.         6.         6.         5.         5.         5.
      4.         4.         4.         4.         3.         3.         3.         3.         2.         2.
      2.         2.         2.         2.         2.         2.         1.         1.         1.         1.
      1.         1.         1.         1.         1.         1.         1.         1.         1.         1.
      1.         1.         0.         0.         0.         0.         0.         0.         0.         0.
      0.         0.         0.         0.         0.         0.         0.         0.         0.         0.

                                                  STAGE
  1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0
  1036.0     1036.0     1036.0     1036.0     1036.0     1036.1     1036.1     1036.2     1036.3     1036.3
  1036.4     1036.5     1036.6     1036.7     1036.8     1036.9     1037.0     1037.3     1037.6     1038.1
  1038.6     1039.1     1039.7     1040.4     1041.0     1041.5     1041.9     1042.0     1041.9     1041.6
  1041.3     1040.8     1040.4     1039.9     1039.6     1039.2     1038.9     1038.6     1038.4     1038.1
  1037.9     1037.8     1037.7     1037.5     1037.4     1037.4     1037.3     1037.2     1037.2     1037.1
  1037.1     1037.0     1037.0     1037.0     1036.9     1036.9     1036.8     1036.8     1036.8     1036.7
  1036.7     1036.6     1036.6     1036.5     1036.5     1036.5     1036.5     1036.4     1036.4     1036.4
  1036.4     1036.3     1036.3     1036.3     1036.3     1036.3     1036.2     1036.2     1036.2     1036.2
  1036.2     1036.2     1036.2     1036.1     1036.1     1036.1     1036.1     1036.1     1036.1     1036.1
  1036.1     1036.1     1036.1     1036.1     1036.1     1036.1     1036.1     1036.1     1036.1     1036.0
  1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0
  1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0
  1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0
  1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0     1036.0

PEAK OUTFLOW IS      4201. AT TIME  13.00 HOURS


                                 PEAK    6-HOUR    24-HOUR    72-HOUR   TOTAL VOLUME
                       CFS      4201.     3228.      1216.       427.         61461.
                       CMS       121.       91.        34.        12.          1740.
                    INCHES                5.41       8.16       8.58           8.58
                        MM              137.43     207.37     218.05         218.05
                     AC-FT               1601.      2415.      2540.          2540.
                THOUS CU M               1974.      2979.      3132.          3133.


                                          STATION      2, PLAN 1, RATIO 3
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                                        END-OF-PERIOD HYDROGRAPH ORDINATES

                                                   OUTFLOW
       1.          2.          2.          3.          3.          3.          3.          3.          3.          3.
       3.          3.          3.          3.         11.         21.         36.         61.         89.        119.
     144.        172.        277.        233.        274.        333.        426.        579.        828.       1193.
    1657.       2145.       2817.       3731.       4643.       5443.       5994.       6151.       5923.       5429.
    4827.       4125. [illegible]      2956.       2525.       2124.       1814.       1542.       1317.       1139.
     977. [illegible]        742.        676.        624.        576.        536.        498.        463.        431.
     402.        374.        347.        325.        304.        283.        264.        246.        235.        225.
     215.        205.        194.        184.        174.        164.        155.        145.        137.        128.
     120.        113.        105.         99.         92.         86.         81.         76.         71.         66.
      62.         58.         54.         50.         47.         44.         41.         38.         36.         33.
      31.         29.         27.         25.         23.         22.         20.         19.         18.         17.
      15.         14.         14.         13.         12.         11.         10.         10.          9.          8.
       8.          7.          7.          6.          6.          6.          5.          5.          4.          4.
       4.          4.          3.          3.          3.          3.          3.          2.          2.          2.
       2.          2.          2.          2.          1.          1.          1.          1.          1.          1.

                                                   STORAGE
       0.          0.          0.          1.          1.          1.          1.          1.          1.          1.
       1.          1.          1.          1.          2.          4.          8.         12.         18.         24.
      30.         35.         41.         46.         51.         58.         67.         83.        106.        136.
     169.        203.        243.        295.        341.        380.        406.        413.        402.        380.
     350.        317.        245.        233.        226.        201.        180.        161.        145.        131.
     118.        104.        100.         93.         83.         83.         79.         75.         71.         66.
      65.         62.         59.         57.         55.         52.         50.         49.         47.         45.
      43.         41.         39.         37.         35.         33.         31.         29.         27.         26.
      24.         22.         21.         20.         18.         17.         16.         15.         14.         13.
      12.         11.         11.         10.          9.          9.          8.          8.          7.          7.
       6.          5.          5.          5.          5.          4.          4.          4.          4.          3.
       3.          3.          3.          3.          2.          2.          2.          2.          2.          2.
       2.          1.          1.          1.          1.          1.          1.          1.          1.          1.
       1.          1.          1.          1.          1.          1.          1.          0.          0.          0.
       0.          0.          0.          0.          0.          0.          0.          0.          0.          0.

                                                    STAGE
   1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0
   1036.0      1036.0      1036.0      1036.0      1036.0      1036.1      1036.2      1036.3      1036.4      1036.5
   1036.6      1036.7      1036.9      1037.0      1037.1      1037.2      1037.4      1037.7      1038.2      1038.7
   1039.3      1040.0      1040.8      1041.6      1042.3      1043.0      1043.4      1043.5      1043.3      1043.0
   1042.5      1041.9      1041.4      1040.9      1040.4      1039.9      1039.5      1039.2      1038.9      1038.6
   1038.4      1038.2      1038.0      1037.9      1037.8      1037.7      1037.6      1037.5      1037.5      1037.4
   1037.3      1037.3      1037.2      1037.2      1037.1      1037.1      1037.0      1037.0      1037.0      1036.9
   1036.9      1036.8      1036.8      1036.8      1036.7      1036.7      1036.6      1036.6      1036.6      1036.5
   1036.5      1036.5      1036.4      1036.4      1036.4      1036.4      1036.3      1036.3      1036.3      1036.3
   1036.3      1036.2      1036.2      1036.2      1036.2      1036.2      1036.2      1036.2      1036.1      1036.1
   1036.1      1036.1      1036.1      1036.1      1036.1      1036.1      1036.1      1036.1      1036.1      1036.1
   1036.1      1036.1      1036.1      1036.1      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0
   1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0
   1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0
   1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0

PEAK OUTFLOW IS      6151. AT TIME  19.00 HOURS


                               PEAK     6-HOUR     24-HOUR    72-HOUR    TOTAL VOLUME
                   CFS        6151.      4634.      1741.       610.          87799.
                   CMS         174.       131.        49.        17.           2486.
                INCHES                    7.77      11.67      12.26           12.26
                                        197.29     296.51     311.47          311.49
                AC-FT                2247.     3454.     3628.          3628.
           THOUS CU M                2771.     4257.     4475.          4475.


                                      STATION       2, PLAN 1, RATIO 4

                                      END-OF-PERIOD HYDROGRAPH ORDINATES

                                                  OUTFLOW
         1.          2.          3.          3.          4.          4.          4.          4.          4.          4.
         4.          4.          4.          7.         14.         26.         50.         80.        115.        154.
       194.        233.        241.        344.        391.        456.        570.        773.       1134.       1619.
      2214.       2970.       3533.       4990.       6151.       7205.       7910.       8056.       7660.       6954.
      6193.       5559.       4542.       3827.       3213.       2712.       2284.       1954.       1676.       1433.
      1239.       1076.        953.        854.        782.        720.        676.        633.        593.        554.
       515.        484.        452.        422.        391.        366.        343.        320.        299.        279.
       260.        243.        233.        223.        213.        203.        192.        182.        172.        162.
       153.        143.        135.        126.        119.        111.        104.         97.         91.         85.
        80.         74.         70.         65.         61.         57.         53.         49.         46.         43.
        40.         38.         35.         33.         31.         28.         27.         25.         23.         22.
        20.         19.         18.         16.         15.         14.         13.         12.         12.         11.
        10.          9.          9.          8.          8.          7.          7.          6.          6.          5.
         5.          5.          4.          4.          4.          4.          3.          3.          3.          3.
         3.          2.          2.          2.          2.          2.          2.          2.          1.          1.

                                                  STORAGE
         0.          0.          1.          1.          1.          1.          1.          1.          1.          1.
         1.          1.          1.          1.          3.          6.         10.         16.         23.         31.
        39.         45.         53.         59.         64.         70.         82.        102.        131.        167.
       207.        252.        302.        356.        413.        454.        487.        493.        478.        450.
       415.        375.        336.        299.        266.        237.        212.        191.        171.        154.
       139.        126.        115.        109.        103.         98.         93.         89.         85.         81.
        77.         73.         70.         67.         64.         61.         59.         56.         54.         52.
        50.         48.         46.         44.         42.         40.         38.         36.         34.         32.
        30.         29.         27.         25.         24.         22.         21.         19.         18.         17.
        16.         15.         14.         13.         12.         11.         11.         10.          9.          9.
         8.          7.          7.          7.          6.          6.          5.          5.          5.          4.
         4.          4.          3.          3.          3.          3.          3.          2.          2.          2.
         2.          2.          2.          2.          2.          1.          1.          1.          1.          1.
         1.          1.          1.          1.          1.          1.          1.          1.          1.          1.
         0.          0.          0.          0.          0.          0.          0.          0.          0.          0.

                                                   STAGE
    1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0
    1036.0      1036.0      1036.0      1036.0      1036.1      1036.1      1036.2      1036.3      1036.5      1036.6
    1036.9      1037.0      1037.1      1037.2      1037.3      1037.4      1037.7      1038.1      1038.6      1039.3
    1040.0      1040.8      1041.7      1042.5      1043.5      1044.2      1044.6      1044.7      1044.5      1044.1
    1043.5      1042.9      1042.3      1041.6      1041.1      1040.5      1040.1      1039.7      1039.4      1039.1
    1038.8      1038.5      1038.4      1038.2      1038.1      1038.0      1037.9      1037.8      1037.7      1037.7
    1037.6      1037.5      1037.4      1037.4      1037.3      1037.3      1037.2      1037.2      1037.1      1037.1
    1037.0      1037.0      1037.0      1036.9      1036.9      1036.8      1036.8      1036.8      1036.7      1036.7
    1036.6      1036.6      1036.6      1036.5      1036.5      1036.5      1036.4      1036.4      1036.4      1036.4
    1036.3      1036.3      1036.3      1036.3      1036.3      1036.2      1036.2      1036.2      1036.2      1036.2
    1036.2      1036.2      1036.1      1036.1      1036.1      1036.1      1036.1      1036.1      1036.1      1036.1
    1036.1      1036.1      1036.1      1036.1      1036.1      1036.1      1036.1      1036.1      1036.0      1036.0
    1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0
    1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0
    1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0      1036.0

PEAK OUTFLOW IS      8056. AT TIME  19.00 HOURS
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            [illegible]  [illegible]  [illegible]  72-HOUR  TOTAL VOLUME
CFS         [illegible]  [illegible]  [illegible]   793.       114134.
CMS         [illegible]     171.      [illegible]    22.         3232.
INCHES                   [illegible]     15.19     15.94         15.94
MM                       [illegible]    385.81    404.90        404.93
AC-FT                    [illegible]  [illegible]  4716.          4716.
THOUS CU M                 3?93.      [illegible]  5817.          5816.

                    STATION      2, PLAN 1, RATIO 5

              END-OF-PERIOD HYDROGRAPH ORDINATES

                              OUTFLOW
       2.          3.          4.          4.          5.          5.          5.          5.          5.          5.
       5.  [illegible] [illegible]         3.         17.         34.         61.         98.        142.        190.
[illegible] [illegible] [illegible] [illegible] [illegible]       570.        707.        998.       1428.       2044.
[illegible] [illegible] [illegible] [illegible]      7733.       9355.      10219.       9970.       9182.       8228.
    7421. [illegible] [illegible] [illegible] [illegible]       3278.       2775.       2350.       2015.       1738.
[illegible] [illegible] [illegible] [illegible]       956. [illegible]       816.        757.        708.        668.
[illegible] [illegible] [illegible]       516.        483.        451.        421.        393.        367.        343.
[illegible] [illegible] [illegible] [illegible]       243.        233.        223.        213.        203.        192.
     162. [illegible]        152. [illegible]       143.        135.        126.        118.        111.        104.
      97.         91. [illegible] [illegible]        74.         70.         65.         61.         57.         53.
[illegible] [illegible] [illegible] [illegible]        38.         35.         33.         31.         28.         27.
      25.         23.         22.         20.         19. [illegible]        16.         15.         14.         13.
      12.         12.         11.         10.          9.          9.          8.          8.          7.          7.
       6.          6.          5.          5.          5.          4.          4.          4.          4.          3.
       3.          3.          3.          3.          2.          2.          2.          2.          2.          2.

                              STORAGE
       0.          1.          1.          1.          1.          1.          1.          1.          1.          1.
       1.          1.          1.          2.          3.          7.         12.         20.         28.         38.
[illegible] [illegible] [illegible] [illegible]        74.         82.         96.        120.        153.        196.
     213. [illegible]        352.        417. [illegible]       523.        537.        533.        520.        499.
     468. [illegible] [illegible] [illegible] [illegible]       254.        240.        215.        194.        175.
     154.        143.        132.        124.        117.        111.        105.        101.         97.         92.
[illegible] [illegible] [illegible]        77.         73.         70.         67.         64.         61.         59.
[illegible] [illegible]         52.         50.         45.         45.         44.         42.         40.         38.
[illegible] [illegible]         32.         30.         29.         27.         25.         24.         22.         21.
      19. [illegible]         17.         16.         15.         14.         13.         12.         11.         11.
      10. [illegible]          9.          8.          7.          7.          7.          6.          6.          5.
       5. [illegible]          4.          4.          4.          3.          3.          3.          3.          3.
       2.          2.          2.          2.          2.          2.          2.          2.          1.          1.
       1.          1.          1.          1.          1.          1.          1.          1.          1.          1.
       1.          1.          1.          0.          0.          0.          0.          0.          0.          0.

                              STAGE
[illegible] [illegible] [illegible] [illegible]     1036.0      1036.0      1036.0      1036.0      1036.0      1036.0
[illegible] [illegible] [illegible] [illegible]     1036.1      1036.1      1036.3      1036.4      1036.6      1036.8
[illegible]     1037.2      1037.3      1037.4      1037.5      1037.7      1038.0      1038.4      1039.1      1039.8
[illegible] [illegible]     1042.5 [illegible] [illegible]     1045.2      1045.4      1045.4      1045.2      1044.8
   1044.3 [illegible] [illegible]     1042.3      1041.7      1041.1      1040.6      1040.2      1039.8      1039.4
[illegible] [illegible]     1038.7 [illegible] [illegible]     1038.2      1038.1      1038.1      1038.0      1037.9
   1037.4      1037.7      1037.6      1037.6      1037.5      1037.4      1037.4      1037.3      1037.3      1037.2
[illegible]     1037.1      1037.1 [illegible]     1037.0      1037.0      1036.9      1036.9      1036.8      1036.8
[illegible] [illegible] [illegible] [illegible] [illegible]     1036.6      1036.5      1036.5      1036.5      1036.4
   1036.4 [illegible] [illegible]     1036.3      1036.3      1036.3      1036.3      1036.3      1036.2      1036.2
   1036.2    1036.2    1036.2    1036.2    1036.2    1036.1    1036.1    1036.1    1036.1    1036.1
   1036.1    1036.1    1036.1    1036.1    1036.1    1036.1    1036.1    1036.1    1036.1    1036.1
   1036.1    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0
   1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0
   1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0

PEAK OUTFLOW IS     10219. AT TIME  16.50 HOURS

                          PEAK    6-HOUR    24-HOUR    72-HOUR   TOTAL VOLUME
                  CFS    10219.    7445.     2791.       975.       140477.
                  CMS      289.     211.       79.        28.         3978.
               INCHES              12.46     18.71      19.62         19.62
                   MM             316.46    475.33     498.34        498.37
                AC-FT              3692.     5535.      5574.         5605.
        THOUS CU M                 4554.     6829.      7166.         7169.

                            STATION      2, PLAN 1, RATIO 6

                         END-OF-PERIOD HYDROGRAPH ORDINATES

                                       OUTFLOW
       2.        3.        5.        5.        5.        5.        6.        6.        6.        6.
       6.        6.        7.       11.       21.       43.       77.      123.      178.      236.
     343.      433.      502.      569.      629.      714.      929.     1276.     1845.     2639.
    3612.     4771.     6212.     7997.    10673.    12226.    12760.    12439.    11391.    10069.
    8720.     7354.     6347.     5659.     4773.     4020.     3405.     2893.     2469.     2114.
    1833.     1594.     1406.     1261.     1181.     1093.     1014.      944.      879.      819.
     763.      714.      675.      635.      597.      559.      524.      490.      456.      428.
     399.      373.      348.      325.      303.      283.      264.      246.      235.      225.
     215.      205.      194.      184.      174.      164.      154.      145.      137.      128.
     120.      113.      105.       99.       92.       86.       81.       75.       71.       66.
      62.       57.       54.       50.       47.       44.       41.       38.       36.       33.
      31.       29.       27.       25.       23.       22.       20.       19.       18.       17.
      16.       14.       14.       13.       12.       11.       10.       10.        9.        8.
       8.        7.        7.        6.        6.        6.        5.        5.        4.        4.
       4.        4.        3.        3.        3.        3.        3.        2.        2.        2.

                                       STORAGE
       0.        1.        1.        1.        1.        1.        1.        1.        1.        1.
       1.        1.        1.        2.        4.        9.       15.       24.       35.       47.
      59.       68.       75.       82.       88.       98.      114.      142.      162.      232.
     293.      347.      410.      490.      544.      566.      574.      569.      555.      535.
     511.      479.      436.      390.      347.      309.      276.      247.      222.      201.
     181.      165.      152.      142.      134.      127.      121.      116.      110.      106.
     101.       97.       93.       89.       85.       81.       77.       74.       71.       67.
      64.       62.       59.       57.       54.       52.       50.       49.       47.       45.
      43.       41.       39.       37.       35.       33.       31.       29.       27.       26.
      24.       22.       21.       20.       18.       17.       16.       15.       14.       13.
      12.       11.       11.       10.        9.        9.        8.        8.        7.        7.
       6.        5.        5.        5.        5.        4.        4.        4.        4.        3.
       3.        3.        3.        3.        2.        2.        2.        2.        2.        2.
       2.        1.        1.        1.        1.        1.        1.        1.        1.        1.
       1.        1.        1.        1.        1.        1.        1.        0.        0.        0.

                                        STAGE
   1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0    1036.0
   1036.0    1036.0    1036.0    1036.0    1036.1    1036.2    1036.3    1036.5    1036.7    1037.0
   1037.2    1037.4    1037.6    1037.7    1037.8    1038.0    1038.3    1038.8    1039.6    1040.5
```

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[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   [illegible]   [illegible]   1045.9   1045.7   [illegible]
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   [illegible]   [illegible]   1040.7   1040.3   1039.9
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   [illegible]   1037.4   1038.3   1038.2   1038.1
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   1037.7   1037.6   1037.5   1037.5   1037.4
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   1037.1   1037.0   1037.0   1037.0   1036.9
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   1036.7   1036.6   1036.6   1036.6   1036.5
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   1036.4   1036.3   1036.3   1036.3   1036.3
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   1036.2   1036.2   1036.2   1036.1   1036.1
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   1036.1   1036.1   1036.1   1036.1   1036.1
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   1036.0   1036.0   1036.0   1036.0   1036.0
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   1036.0   1036.0   1036.0   1036.0   1036.0
[illegible]   [illegible]   [illegible]   [illegible]   [illegible]   1036.0   1036.0   1036.0   1036.0   1036.0

[illegible]

                               PEAK     6-HOUR    24-HOUR    72-HOUR   TOTAL VOLUME
                     CFS  [illegible]   9337.      5491.      1219.        175593.
                     CMS  [illegible]   264.   [illegible]     35.          4972.
                  INCHES               15.66      23.40      24.52          24.55
                      MM               397.7      594.45     622.91         622.96
                   AC-FT               4630.   [illegible]    7255.          7256.
              THOUS CU M               5711.   [illegible]    8949.          8950.

**********          **********          **********          **********          **********
```

```
PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
              FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
                   AREA IN SQUARE MILES (SQUARE KILOMETERS)

                                                                      RATIOS APPLIED TO FLOWS
OPERATION      STATION        AREA     PLAN   RATIO 1   RATIO 2   RATIO 3   RATIO 4   RATIO 5   RATIO 6
                                                 0.20      0.35      0.50      0.65      0.80      1.00

HYDROGRAPH AT             1     5.55       1     2562.     4484.     6405.     8327.    10249.    12811.
                          (    14.37)      (    72.55)(  126.97)(  181.37)(  235.80)(  290.21)(  362.76)(
ROUTED TO                 2     5.55       1     2556.     4261.     6151.     8056.    10219.    12760.
                          (    14.37)      (    72.31)(  120.65)(  174.19)(  228.11)(  289.37)(  361.32)(
                                   SUMMARY OF DAM SAFETY ANALYSIS

 PLAN  1 ...............                INITIAL VALUE      SPILLWAY CREST      TOP OF DAM
                        ELEVATION          1036.00            1036.00           1044.80
                        STORAGE               0.                 0.               497.
                        OUTFLOW               0.                 0.              8152.

        RATIO       MAXIMUM        MAXIMUM      MAXIMUM      MAXIMUM     DURATION      TIME OF      TIME OF
         OF        RESERVOIR        DEPTH       STORAGE      OUTFLOW     OVER TOP    MAX OUTFLOW    FAILURE
         PMF       W.S.ELEV.      OVER DAM       AC-FT         CFS         HOURS        HOURS        HOURS

         .20        1041.21          0.00          216.        2368.        0.00        19.00         0.00
         .35        1042.72          0.00          322.        4261.        0.00        19.00         0.00
         .50        1043.57          0.00          413.        6151.        0.00        19.00         0.00
         .65        1044.74          0.00          493.        8055.        0.00        19.00         0.00
         .80        1045.42          0.62          537.       10219.        2.50        18.50         0.00
        1.00        1045.96          1.16          574.       12767.        3.50        18.50         0.00
```

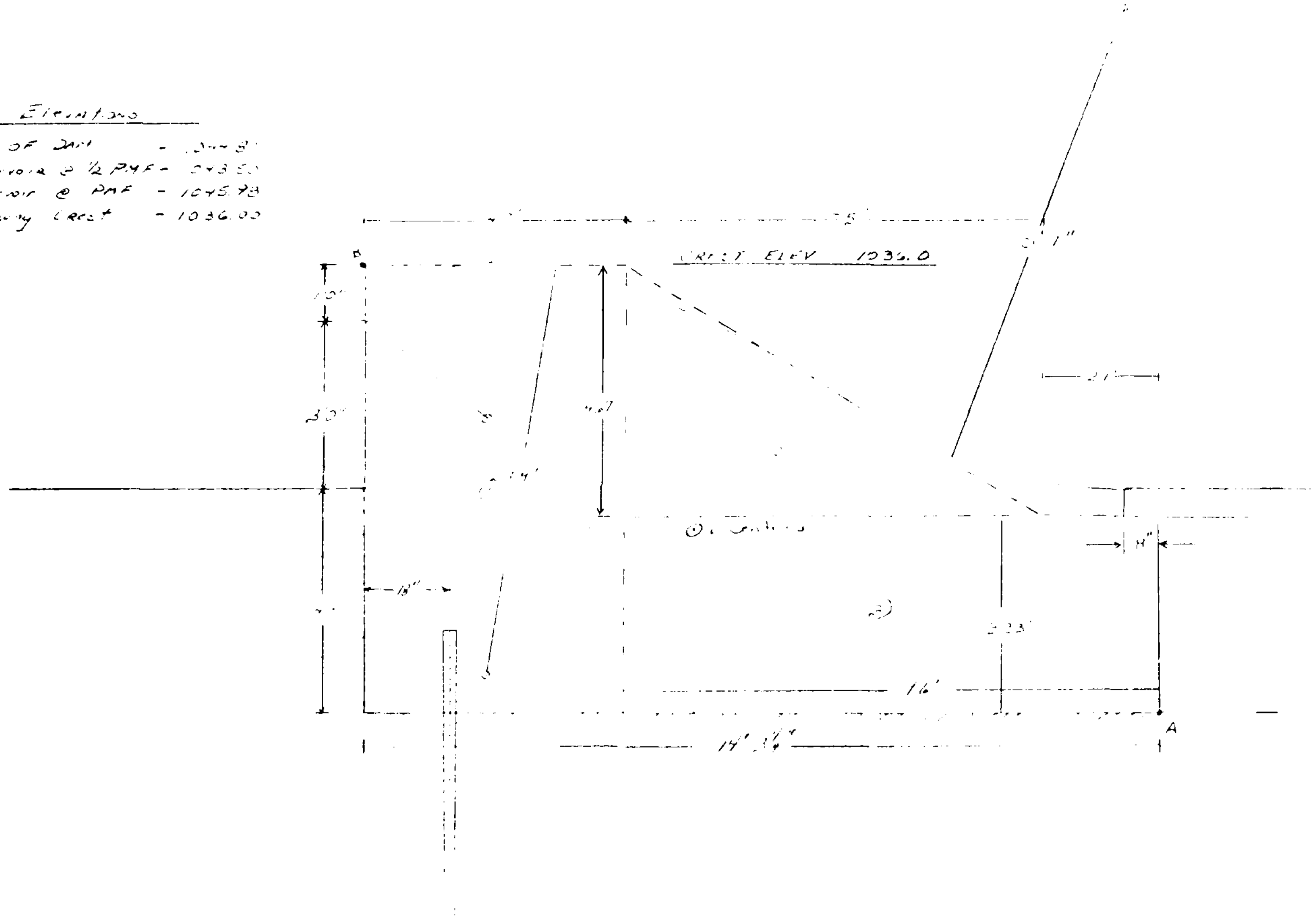
APPENDIX D

STRUCTURAL STABILITY ANALYSIS

BY DATE SUBJECT SHEET NO OF
CHKD BY DATE JOB NO

Elevations

TOP OF DAM - 1044.8
Reservoir @ ½ PMF - 1043.50
Reservoir @ PMF - 1045.78
Spillway Crest - 1036.00



CREST ELEV 1036.0
3'1"
2.7'
4.67
1'0"
3'0"
18"
14"
2.33'
16'
14'1/4"
①
②
③
A
B

[illegible]

FRENCH RESERVOIR DAM

Determine Centroid (Moment about Toe)

Area No.	Area	Arm	Moment
1	8.0×4.7 (37.6)	$9.6+\frac{4.7}{2}$ (11.95)	(449.32)
2.	$\frac{1}{2}\times 4.6\times 7.5$ (17.5)	$2.1+\frac{2}{3}(7.5)$ (7.1)	(124.34)
3.	3.33×9.6 (31.97)	$\frac{9.6}{2}$ (4.8)	(153.45)
	ΣA = 87.08		ΣM = 727.11

$$\bar{y} = \frac{\Sigma M}{\Sigma A} = \frac{727.11}{87.08} = 8.35$$

Area No	Area	Arm	Moment about B
1.	37.6	4.0	150.40
2.	17.51	$\frac{2}{3}(4.67)$	54.51
3.	31.97	$4.67+\frac{3.33}{2}$	202.53
	ΣA = 87.08		ΣM = 407.44

$$\bar{x} = \frac{\Sigma M}{\Sigma A} = \frac{407.44}{87.08} = 4.68$$

[illegible]

2 Weight of Concrete [illegible]
(from [illegible])

Volume = (87.63)(1)

$$\text{Weight} = \frac{(87.63)(1)(150\,\text{pcf})}{1000} = 13.[illegible]\ \text{kips/lin ft}$$

③ Determine Active Earth Pressure (P_A)

$K_a = \tan^2(45° - \phi/2)$

Assume: $\phi = 27°$
$\delta = 0°$ (wall friction)
$\gamma_{sat} = 125$
$\gamma' = 60\,\text{pcf}$

$\sigma_{H\max} = (60)(0.38)(4) = 91.2\,\text{psf}$

$$P_A = \frac{(\sigma_{H\max})(1/2)(4)}{1000} = 0.18\ \text{kips/lin ft}$$

④ Determine Passive Earth Pressure (P_p)

$K_p = \tan^2(45 + \phi/2)$

$K_p = 2.7$

$\sigma_{p\max} = (60)(2.7)(4) = 648\,\text{psf}$

$P_p = (1/2)(\sigma_p)(4) = 1.23$ kips/lin ft

⑤ Determine Water Pressure @ (P_w)

Normal Pool	1036.0
1/2 PMF	104[illegible].00
PMF	104[illegible]8

[illegible] P_{WN}

[illegible] 4 [illegible]

$P_{WN} = \frac{1}{2}(\ldots)(h_N) = \frac{\frac{1}{2}(\ldots)}{1000} = 2$ [illegible]

Resultant acts 2.67' above BASE

2) 1/2 PMF $P_{N_{1/2}}$

$P_{N_{1/2}} = (h_{1/2} - h_N)(h_N)(\gamma_w) + P_{W_N}$

$= \frac{(1043.5 - 1036.0)(30)62.4}{1000} + 2$ [illegible] $= 5.74$ [illegible]

Resultant act 3.54' above BASE

3) PMF $P_{W_{PMF}}$

$P_{W_{PMF}} = (h_{PMF} - h_N)(h_N)(\gamma_w) + P_{W_N}$

$= \frac{(1045.13 - 1036.0)(30)(62.4)}{1000} + 2$ [illegible]

Resultant acts 3.62' above BASE

[illegible] 1/2 Uplift and Uplift for Normal Conditions,
1/2 PMF and PMF

1) Normal Pool

a) Full Uplift

$P_{u_N} = \frac{(499.2\ psf)(1/2)(14.27)}{1000} = 3.5$ [illegible]

c) 1/2 Uplift

$P_{u_{N1/2}} = 1.78$ Kips/lin ft

2) 1/2 PMF

a) Full Uplift

$P_{u_{1/2}} = \frac{(\ldots\ psf)(1/2)(14.27)}{1000} = 6.4$ [illegible]

b) 1/2 [illegible]

$P_{u_{1/2\,1/2}} =$ [illegible]

Sheet 5 of 6

3) PMF

a) Full Uplift

$$P_{u_{PMF}} = \frac{(1121.95)(1/2)(14.27)}{1000} = 8.01 \text{ Kips/lin.ft}$$

b) 1/2 Uplift

$$P_{u_{PMF 1/2}} = 4.00 \text{ Kips/lin.ft.}$$

⑦ Ice Load (P_I)

$$P_{I_{MAX}} = 10{,}000 \text{ lbs/lin.ft} = 10 \text{ Kips/lin.ft}$$

$$P_{I_{MIN}} = 5 \text{ Kips/lin.ft.}$$

⑧ Earthquake - Inertia Force within Dam (P_c)

$$P_c = \lambda W_c = (0.1)(13.06) = 1.31 \text{ Kips/lin.ft.}$$

⑨ Earthquake - Hydrodynamic Force at Normal Pool, 1/2 PMF and PMF

1.) Normal

$$Pe_N = C\lambda\gamma_w h = \frac{(0.73)(0.1)(624)(8)}{1000} = 0.0364 \text{ Ksf}$$

$C = 0.73$

$\lambda = 0.1$

$\gamma_w = 62.4$

$h = 1036 - 1028 = 8$

$$Ve_N = 0.726\, Pe\, h = (0.726)(0.0364)(8) = 0.21 \text{ Kips/lin.ft}$$

$$M_{e_N} = 0.299\, Pe\, h^2 = (0.299)(0.0364)(8)^2 = 0.696 \text{ K·ft/lin.ft}$$

2) [illegible]

$Pe_{max} = \frac{(0.73)(0.1)(62.4)(1037.[illegible] - 102[illegible])}{1000}$ [illegible]

$Pe_{spillway\ crest} = \frac{(0.73)(0.1)(62.4)\sqrt{(7.5)(15.5)}}{1000} = 0.0[illegible]$

$Ve_{1/2} = 0.726[(0.0706)(15.5) - (0.0[illegible])(7.5)]$

$= .794 - .267 = .527$ kips/lin ft

$Me_{1/2} = 0.299(0.0706)(15.5)^2 - \left(\frac{299}{726}(7.5) + 3\right)(0.267)$

$= 5.072 - 2.961 = 2.11$ K-ft/ft

Resultant acts 4.0' above BASE

3) PMF

$Pe_{max} = \frac{(0.73)(0.1)(62.4)(1045.98 - 1028.0)}{1000} = 0.0817$ ksf

$Pe_{spillway\ crest} = \frac{(0.73)(0.1)(62.4)\sqrt{(9.98)(17.98)}}{1000} = 0.061$ ksf

$Ve_{PMF} = 0.726[(0.0817)(17.98) - (0.061)(9.98)]$

$= 1.069 - .442 = 0.627$ Kips/lin ft

$Me_{PMF} = 0.299(0.0819)(17.98)^2 - \left(\frac{299}{726}(9.98) + 3\right)(0.442)$

$= 7.92 - 5.35 = 2.57$ Kips/lin ft

Resultant acts 4.10' above BASE

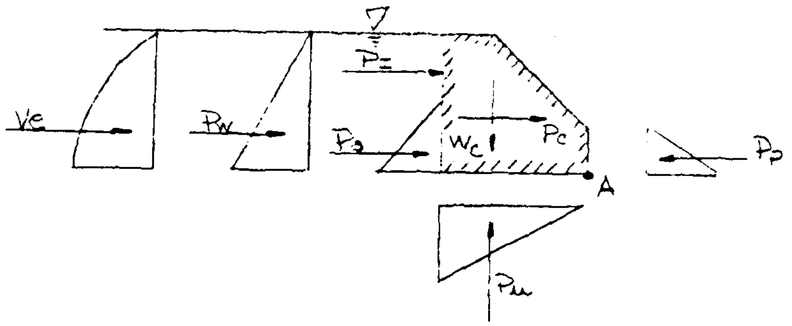
[illegible]

Normal Pool with the following loading conditions

A. Full Hydrostatic Uplift Force

B. Maximum Ice Load

C. Earthquake



A. Overturning Stability

1) Overturning Moments

Force	Magnitude (kips)	Moment Arm (ft)	Moment (kip-ft)
Pw	2.00	2.7	5.34
Pu	3.56	9.5	33.86
PA	0.18	1.3	0.24
PI	10.0	7.0	70.00
Pc	1.31	3.3	4.33
Ve	0.21	3.3	0.70
			$\Sigma M_o = 114.4$[illegible]

2) Resisting Moments

Wc	13.06	8.4	109.02
Pp	1.29	1.3	1.69
			$\Sigma M_R =$ [illegible]

$$\boxed{F.S. = \frac{\Sigma M_R}{\Sigma M_o} = \frac{110.71}{114.4} = 0.97}$$

$$\bar{x} = \frac{\Sigma M_R - \Sigma M_O}{\Sigma F_V} = \frac{[illegible]}{[illegible]} = -.39$$

$$e = B/2 - \bar{x} = \frac{14.27}{2} - (-.39) = 7.53$$

$$\boxed{B/6 = \frac{14.27}{6} = 233 < 7.53}$$

Resultant is Outside the base ∴ NOT STABLE

B. Sliding Stability

$$SF_{S-F} = \frac{cA + (W_c - F_u)\tan\phi}{\Sigma F_H}$$

Assume
$c = 500$ psf
$A = 14.27\ ft^2$
$\phi = 26°$

$$SF = \frac{\frac{(500)(14.27)}{100} + 13.06 - 3.56(0.49)}{2.0 + 0.18 + 10.0 + 1.31 + 0.21 - 1.30} = \boxed{0.95}$$

Saftey Factor is less than 1.5 - the minimum sliding friction saftey factor recommended by the Guidelines For Saftey Inspection of Dams

STABILITY PROGRAM (HP-97)

CALCULATOR PRINT OUT

	RESERVOIR ELEVATION	333.32 ***
OVERTURNING MOMENTS	Water Pressure	7.33 ***
	Moment Arm	5.1 ***
	Hydrostatic Uplift Pressures	5.77 ***
	Moment Arm	14.3 ***
	Active Earth Pressure	2.75 ***
	Moment Arm	2.3 ***
	Silt Load	3.20 ***
	Moment Arm	8.1 ***
	Ice Load	13.33 ***
	Moment Arm	14.5 ***
	Seismic-Inertial Force	7.14 ***
	Moment Arm	5.1 ***
	Seismic-Hydrodynamic Force	3.73 ***
	Moment Arm	6.4 ***
RESISTING MOMENTS	Weight of Concrete	
	Moment	71.44 ***
		14.6 ***
	Passive Earth Pressure	
	Moment Arm	1.73 ***
		1.1 ***

Sum of Resisting Moments	457.33 ***
Sum of Overturning Moments	288.32 ***
Safety Factor-Overturning	1.59 ***
Eccentricity	4.52 ***
Safety Factor-Sliding	17.72 ***

NORMAL POOL 1/2 Uplift	NORMAL POOL 1/2 Uplift & Ice
1036.00	1036.00
2.00	2.00
2.7	2.7
1.78	1.78
9.5	9.5
0.18	0.18
1.3	1.3
0.00	0.00
0.0	0.0
0.00	10.00
7.0	7.0
0.00	0.00
3.3	3.3
0.00	0.00
3.3	3.3
13.06	13.06
8.3	8.3
1.26	1.26
1.3	1.3
110.77	110.77
22.51	22.51
4.92	1.20
-0.69	5.52
14.06	1.16

NY 749

NORMAL POOL 1/2 Uplift, Ice and Earthquake	NORMAL POOL Full Uplift
1036.00	1036.00
2.00 2.7	2.00 2.7
1.78 9.5	3.56 9.5
0.18 1.3	0.18 1.3
0.00 0.0	0.00 0.0
10.00 7.0	0.00 7.0
1.31 3.3	0.00 3.3
0.21 3.3	0.00 3.3
13.06 8.3	13.06 8.3
1.28 1.3	1.28 1.3
110.77 97.55	110.77 39.45
1.14	2.81
5.96	-0.37
1.02	13.09

NV 749

NORMAL POOL Full Uplift & Ice	NORMAL POOL Full Uplift, Ice and Earthquake
1036.00	1036.00
2.00	2.00
2.7	2.7
3.56	3.56
9.5	9.5
0.18	0.18
1.3	1.3
0.00	0.00
0.0	0.0
10.00	10.00
7.0	7.0
0.00	1.31
3.3	3.3
0.00	0.21
3.3	3.3
13.06	13.06
8.3	8.3
1.28	1.28
1.3	1.3
110.77	110.77
109.45	114.49
1.01	0.97
7.00	7.53
1.08	0.95

NY 749

1/2 PMF 1/2 Uplift	1/2 PMF 1/2 Uplift and Earthquake
1043.50	1043.50
5.74	5.74
3.54	3.54
3.45	3.45
9.5	9.5
0.18	0.18
1.3	1.3
0.00	0.00
0.0	0.0
0.00	0.00
7.0	7.0
0.00	1.31
3.3	3.3
0.00	0.53
6.4	4.0
13.06	13.06
8.3	8.3
1.28	1.28
1.3	1.3
110.77	110.77
53.37	59.83
2.07	1.85
1.17	1.84
2.55	1.83

1/2 PMF Full Uplift	1/2 PMF Full Uplift and Earthquake
1043.50	1042.50
5.74	5.74
3.54	3.54
6.90	6.90
9.5	9.5
0.18	0.18
1.3	1.3
0.00	0.00
0.0	0.0
0.00	0.00
7.0	7.0
0.00	1.31
3.3	3.3
0.00	0.53
6.4	4.0
13.06	13.06
8.3	8.3
1.28	1.28
1.3	1.3
110.77	110.77
86.18	92.64
1.28	1.20
3.15	4.20
2.19	1.57

NY 749

[illegible] 1/2 Split	[illegible] 1/2 Split and [illegible]
1045.08	1045.08
6.98 3.62	6.98 3.62
4.00 9.5	4.00 9.5
0.18 1.3	0.18 1.3
0.00 0.0	0.00 0.0
0.00 7.0	0.00 7.0
0.00 3.3	1.31 3.3
0.00 7.4	0.73 4.1
13.06 8.3	13.06 8.3
1.28 1.3	1.28 1.3
110.77 93.55	110.77 70.47
1.74	1.57
1.93	2.70
1.97	1.48

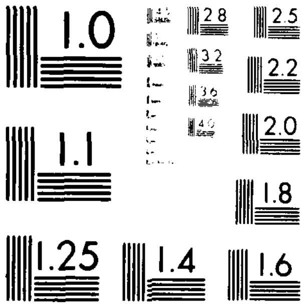
NY 749

AD-A091 138   NEW YORK STATE DEPT OF ENVIRONMENTAL CONSERVATION ALBANY   F/G 13/13
NATIONAL DAM SAFETY PROGRAM. FREDONIA RESERVOIR (INVENTORY NUMB--ETC(U)
SEP 80 B L THOMSEN, G L WOOD   DACW51-79-C-0001

UNCLASSIFIED   NL

2 OF 2
AD
A091138

END
DATE
FILMED
11-80
DTIC


1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

PMF Full Uplift	PMF Full Uplift & Earthquake
1045.98	1045.98
6.98	6.98
3.62	3.62
8.01	8.01
9.5	9.5
0.18	0.18
1.3	1.3
0.00	0.00
0.0	0.0
0.00	0.00
7.0	7.0
0.00	1.31
3.3	3.3
0.00	0.63
7.4	4.1
13.06	13.06
8.3	8.3
1.28	1.28
1.3	1.3
110.77	110.77
101.69	108.61
1.09	1.02
5.35	6.72
1.64	1.23

NY 749

APPENDIX E

Available Documents

M058 has been reconstructed
10/77

Form IW31 6-18-13 2000 (16 1588)

(NOTICE: After filling out one of these forms as completely as possible for each dam in your district, return it at once to the Conservation Commission, Albany.)

STATE OF NEW YORK
CONSERVATION COMMISSION
ALBANY

608 Erie

Map 3-D.

DAM REPORT

June 21, 1915
(Date)

CONSERVATION COMMISSION,

DIVISION OF INLAND WATERS.

GENTLEMEN:

I have the honor to make the following report in relation to the structure known as the Fredonia Upper Reservoir Dam.

This dam is situated upon the Reservoir Pond (Give name of stream)

in the Town of Pomfret, Chautauqua County,

about 3 1/2 mile (State distance) from the Village ~~or City~~ of Fredonia.

The distance down (Up or down) stream from the dam, to the Canadaway Creek (Give name of nearest important stream or of a bridge),

is about 1/2 mile (State distance).

The dam is now owned by Village of Fredonia (Give name in full)

and was built in or about the year 1896, and was extensively repaired or reconstructed during the year 1912.

As it now stands, the spillway portion of this dam is built of concrete (State whether of masonry, concrete or timber)

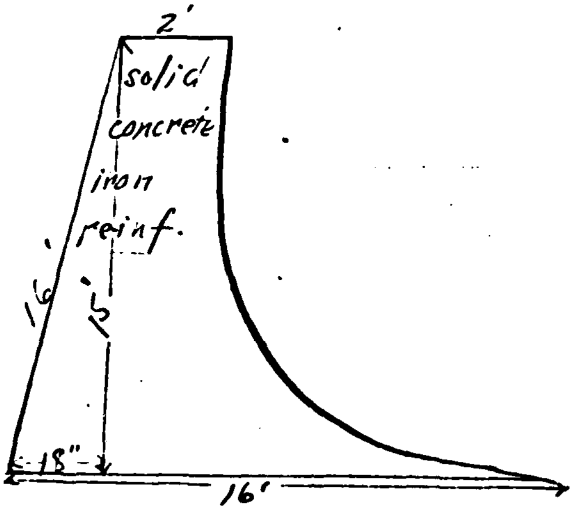
and the other portions are built of earth, masonry and concrete (State whether of masonry, concrete, earth or timber with or without rock fill)

As nearly as I can learn, the character of the foundation bed under the spillway portion of the dam is solid rock and under the remaining portions such foundation bed is earth and rock.

(In the space below, make one sketch showing the form and dimensions of a cross section through the spillway or waste-weir of this dam, and a second sketch showing the same information for a cross section through the other portion of the dam. Show particularly the greatest height of the dam above the stream bed, its thickness at the top, and thickness at the bottom, as nearly as you can learn.)

I

Cross section of Spillway.



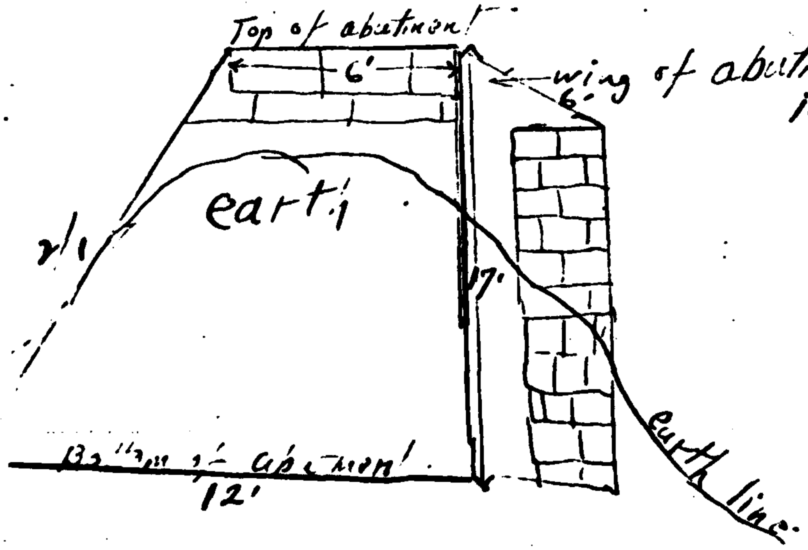
2'
solid concrete iron reinf.
16'
15'
18"
16'

Cross of Dam below.

(In the space below, make a third sketch showing the general plan of the dam, and its approximate position in relation to buildings or other conspicuous objects in the vicinity.)

II.

Cross of Dam.



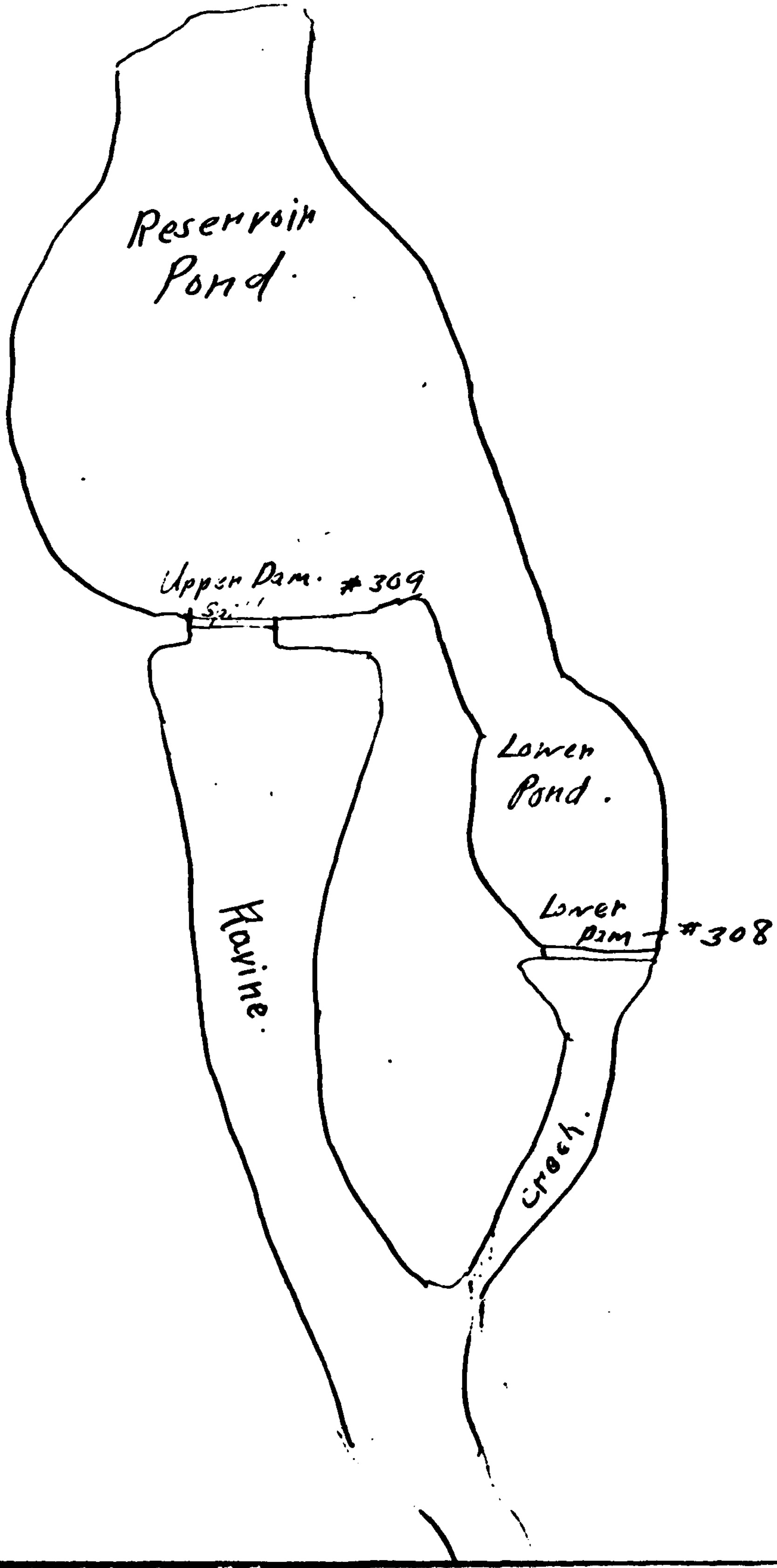
Top of abutment
6'
wing of
6'
earth
17'
Bottom of abutment.
12'
earth line.

abutment – extends inland at 45° is 6' long – 2½' thick of Masonry with 12" concrete top. Is same height as abutment or 17'

General Plan of Dam inside.

111

General Plan of Dam and Surroundings.


Reservoir Pond.
Upper Dam. #309
Spill
Lower Pond.
Lower Dam #308
Ravine.
Creek.

The total length of this dam is 90 feet. The spillway or waste-weir portion, is about 30 feet long, and the crest of the spillway is about 2 feet below the top of the dam.

The number, size and location of discharge pipes, waste pipes or gates which may be used for drawing off the water from behind the dam, are as follows: one discharge pipe – 16" diameter

State briefly, in the space below, whether, in your judgment, this dam is in good condition, or bad condition, describing particularly any leaks or cracks which you may have observed.)

This dam is in very good condition. A part of it went out, – one of the abutments, – two years ago, but has since been replaced and is strong.

The ravine, noted in Drawing III, was dug to take care of the overflow of the pond which would pour over the crest. The pond is fed by springs. and a small creek and covers an approximate area of twenty acres, with an average depth of 12 ft. The creek leading from the lower dam, leads into the Canadaway Creek. Should either of these dams give way it would cause serious damage to the homes and farms along Canadaway Creek especially in the village of Laona which is a hamlet about 2 miles below the dam.

Reported by Carl B. Cooper.
(Signature)

Box 697
(Address—Street and number, P. O. Box or R. F. D. route)

Fredonia N.Y.
(Name of place)

(SEE OTHER SIDE)

REPORT OF
PROPOSAL TO INCREASE
RESERVOIR CAPACITY
FOR
FREDONIA, NEW YORK

FRETTS, TALLAMY & SENIOR
CONSULTING ENGINEERS

on an increased population of 880 persons with the increase in consumption proportioned on the basis of the present consumption. Table IV of the appendix adds these increases to 1934 consumption and shows the estimated total consumption by months for 1956.

Table V of the appendix summarizes the consumption, percolation and evaporation as estimated for the year 1956 and totals each by months. This shows that the consumption varies from a low of 32,830,000 gallons for the month of November to a high of 45,950,000 for the month of July, with a total yearly consumption of approximately 475,330,000 gallons.

GENERAL DESCRIPTION OF THE PROPOSED WORK

It is recommended that the Village of Fredonia increase their reservoir capacity. To accomplish this purpose the writers have investigated several possible locations for a dam on the West Branch of the Canadaway Creek but after study it was considered most feasible and economical to increase the storage of the 90,000,000 gallon reservoir. The writers recommend that this be accomplished by raising the existing earth dam by constructing a smaller and new earthen dam in the present spillway location, and by constructing a new concrete spillway between these two dams and discharging same through a concrete spillway channel into the lower reservoir.

It is not considered advisable to raise the existing dam by adding to the height of the present corewall and placing more fill on the present dam because it is an old structure and it is not known how well the corewall is sealed to rock or other impervious stratum. Therefore, it is recommended that a new corewall be constructed at the downstream toe of the present dam and placing a new fill around this. Then the old dam will be used as a part of the upstream fill of the new dam as shown on the plans which are attached to the petition to the Water Power and Control Commission.

By raising the elevation of the water level in this reservoir twenty feet, 245,000,000 gallons of storage will be created over and above the 90,000,000 gallons stored at present, thus increasing storage capacity by 2-7/10 times the amount now stored. The lake created by the raising of these dams will have an area of approximately fifty acres.

THE CHARACTER OF WATERSHED AREA TRIBUTARY TO THE POINT OF DIVERSION

The tributary watershed area at the point of diversion is approximately five square miles. The terrain is of a steep hilly nature, fairly well wooded and only sparsely inhabited. There is no danger of excessive contamination of the raw water and the modern filtration plant which the Village now maintains and operates will unquestionably eliminate any objectionable bacteria before the water is turned into the distribution system.

ESTIMATED YIELD OF WATERSHED

Table VI of the appendix shows the estimates of watershed yield as based on the 1930 rainfall. Use of rainfall data for that year gave a minimum figure for the summer and fall months. The percentage run off was estimated from watersheds having similar characteristics and from these factors the yield was computed in millions of gallons per month and totals 980 million gallons per year.

Table VII of the appendix was compiled in order to compare by months the yield of the watershed and the present consumption. The table indicates conclusively the previous statement that the Village of Fredonia is in need of additional storage. It is interesting to note that the table shows the deficiency occurs in the months of June to October inclusive. This is a fact and is borne out by actual records proving the accuracy of factors used.

Table VIII of the appendix shows the theoretical amount of storage required for the year 1956. It shows a deficiency of approximately 172 million gallons. Consumption by months was taken from Table V and the yield from Table VI.

Thus it is indicated by increasing the reservoir capacities to 345 million gallons, the Village will have an adequate safety factor in raw water storage. In other words, twice as much storage will be available as is theoretically required for a year of maximum demand and minimum rainfall.

OTHER POSSIBLE SOURCES OF ADDITIONAL SUPPLY

Two other possible locations for the construction of a new dam and reservoir were given a preliminary study. The lower location investigated lies within the upper end of the present large reservoir and would for this reason cause considerable difficulty in construction of a dam. It would result in increased cost and would render it very difficult to maintain an adequate water supply for the Village during the preliminary stages of construction.

The other location is on the upper end of the watershed area. This site is fairly well adapted for a dam, however, material, equipment and other costs. Table IX of the appendix summarizes the estimated cost while Table X of the appendix summarizes the cost by items of work.

SPILLWAY

The length of the existing spillway of the Fredonia Dam is 60 feet. No records have been kept of the maximum depth of overflow during flood seasons. However, the Superintendent of Water for the Village states that he has observed the flow for the past ten years or so and does not believe that it has acceded 2 feet.

In computing the maximum ten year flood the writers assumed a 3 foot overflow in order to obtain a maximum figure. This represents 1,230 sec. feet.

The proposed spillway is 75 feet long and is capable of discharging 3,320 sec. feet with a 5 foot overflow. This is well over a five hundred year probable flood.

In addition to this there is a further safety factor on either side of the spillway. Before flood water could overtop either of the dams an 8 foot depth of water would be going over the spillway with a discharge of 6,700 sec. feet, besides the enlargement of the spillway opening which would be cut on either side of the spillway by the flood water. This would be accomplished without effecting or overtopping of the dams proper.

Respectfully submitted,

FRETTS, TALLAMY & SENIOR
Consulting Engineers

By B. D. Tallamy
B. D. Tallamy

TABLE IX

SUMMARY OF ESTIMATED COSTS

Item of Cost	Federal Funds	Sponsor's Contribution	Total
a. Labor:			
1. Unskilled	60,720.00		60,720.00
2. Intermediate	3,949.20		3,949.20
3. Skilled	9,038.50		9,038.50
4. Professional & Technical	0.00		0.00
b. Superintendence	1,992.00	1,500.00	3,492.00
c. Material, Equipment and other Costs:			
1. Material and Supplies	17,239.00	11,860.00	29,099.00
2. Equipment Rentals		37,800.00	37,800.00
3. Other direct Costs		13,000.00	13,000.00
TOTAL COST OF PROJECT	$92,938.70	$64,160.00	$157,098.70

TABLE X

ESTIMATE OF COST BY ITEMS OF WORK

Quantity	Unit	Description of Operation or Feature of Work	Unit Price	Total
88,000	C.Y.	Earth Fill	0.80	$70,400.00
2,400	C.Y.	Reinforced Concrete	16.00	38,400.00
2,430	C.Y.	Rock Excavation 4'±	8.00	19,440.00
670	C.Y.	Trench Excavation 4'±	2.00	1,340.00
110	Tons	Steel Sheet Piling	81.00	8,910.00
540	Ft.	10" C.I.P. Connections maintaining present Village supply	4.00	2,160.00
1,120	Ft.	Masonry Gutters	2.40	2,688.00
1,360	Ft.	Stone Underdrains	1.50	2,040.00
35	Acres	Cutting trees, brush, clearing Site	150.00	5,250.00
Lump -		Protecting pipe in existing Tunnel	Bid	505.70
Lump -		Sealing existing tunnels & carefully backfilling as far as New Corewall and sealing again	Bid	2,500.00
Lump -		Contingencies & Cleanup		3,465.00
			TOTAL	$157,098.00

Form F-61
9-11-34-500 (11E-1836)

STATE OF NEW YORK

DEPARTMENT OF PUBLIC WORKS

DIVISION OF ENGINEERING

ALBANY

Received Nov. 21, 1936	Dam No. 3 — 1102
Disposition App. Nov. 21, 1936	Watershed Lake Erie
Foundation inspected	
Structure inspected	

Application for the Construction or Reconstruction of a Dam

Application is hereby made to the Superintendent of Public Works, Albany, N. Y., in compliance with the provisions of Section 948 of the Conservation Law (see last page of this application) for the approval of specifications and detailed drawings, marked Dam and Reservoir No. 2 Fredonia, New York herewith submitted for the {construction ~~reconstruction~~} of a dam herein described. All provisions of law will be complied with in the erection of the proposed dam. It is intended to complete the work covered by the application about June 1937 (Date)

1. The dam will be on West Branch Canadaway Ck. flowing into Canadaway Creek in the town of Pomfret, County of Chautauqua and 3 miles south east of Fredonia (give exact distance and direction from a well-known bridge, dam, village main cross-roads or mouth of a stream)
2. Location of dam is shown on the Dunkirk quadrangle of the United States Geological Survey.
3. The name of the owner is Village of Fredonia
4. The address of the owner is Village Hall, Fredonia, N.Y.
5. The dam will be used for Water supply storage
6. Will any part of the dam be built upon or its pond flood any State lands? No
7. The watershed above the proposed dam is 5 square miles.
8. The proposed dam will create a pond area at the spillcrest elevation of 50 acres and will impound 44,600,000 cubic feet of water.

9. The maximum height of the proposed dam above the bed of the stream is 80 feet ________ inches.

10. The lowest part of the natural shore of the pond is 30 feet vertically above the spillcrest, and everywhere else the shore will be at least over 30 feet above the spillcrest.

11. State if any damage to life or to any buildings, roads or other property could be caused by any possible failure of the proposed dam none apparent

12. The natural material of the bed on which the proposed dam will rest is (clay, sand, gravel, boulders, granite, shale, slate, limestone, etc.) limestone, shale, clay

13. Facing down stream, what is the nature of material composing the right bank?
Big dam - shale, limestone ÷ Smaller dam - clay

14. Facing down stream, what is the nature of the material composing the left bank?
Big dam - limestone, clay ÷ Smaller dam - clay

15. State the character of the bed and the banks in respect to the hardness, perviousness, water bearing, effect of exposure to air and to water, uniformity, etc. both dams have hard limestone beds - banks are shale and clay and are impervious - bottoms very durable - sides also very hard for type of material and have stood up on steep slopes over long periods of exposure.

16. Are there any porous seams or fissures beneath the foundation of the proposed dam?
may be seams below rock surface but given no trouble in old dams.

17. Wastes. The spillway of the above proposed dam will be 75 feet long in the clear; the waters will be held at the right end by a concrete wall the top of which will be 5 feet above the spillcrest, and have a top width of one foot; and at the left end by a concrete wall the top of which will be 5 feet above the spillcrest, and have a top width of one feet.

18. The spillway is designed to safely discharge 3320 cubic feet per second.

19. Pipes, sluice gates, etc., for flood discharge will be provided through the dam as follows:
No piping for flood discharge goes through dams.
Feed piping goes through tunnel in rock below dam but is open only on down stream side of core wall.

20. What is the maximum height of flash boards which will be used on this dam? none

21. Apron. Below the proposed dam there will be an apron built of no apron ________ feet long across the stream, ________ feet wide and ________ feet thick.

22. Does this dam constitute any part of a public water supply? Yes

APPENDIX F

Previous Inspection Reports
October 19, 1977
October 4, 1979

/77)

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DAM INSPECTION REPORT
(By Visual Inspection)

Dam Number	River Basin	Town	County	Hazard Class	Date & Inspector
608	Erie	Fredonia	Chautauqua	~~X~~-C	10/19/77

Stream =   Owner = Vil. Fredonia

Type of Construction

☑ Earth w/Concrete Spillway
☐ Earth w/Drop Inlet Pipe
☐ Earth w/Stone or Riprap Spillway
☐ Concrete
☐ Stone
☐ Timber
☐ Other ______

Use

☑ Water Supply
☐ Power
☐ Recreation - ☐ High Density
☐ Fish and Wildlife
☐ Farm Pond
☐ No Apparent Use-Abandoned
☐ Flood Control
☐ Other ______

Estimated Impoundment Size 45 Acres Estimated Height of Dam above Streambed 30± Ft.

Condition of Spillway

☑ Service satisfactory
☐ In need of repair or maintenance
☑ Auxiliary satisfactory
☐ In need of repair or maintenance

Explain:

Condition of Non-Overflow Section

☑ Satisfactory
☐ In need of repair or maintenance

Explain: Trees (planted)

Condition of Mechanical Equipment

☑ Satisfactory
☐ In need of repair or maintenance

Explain:

Siltation ☐ High ☑ Low

Explain: ?? new siltation from recent storm 9/14/79

Remarks: Reinspected 10/4/79 'C" Haz homes & out bldgs damaged during Storm 9/14/79 heavy erosion in downstream channel - Spillway retaining wall eroded & moved 8" into channel at top similar problem on the south side of wall in past (they used earth anchor tiebacks to support walls

trees need to be removed on embankment (utd) several have been uprooted

[illegible]

Evaluation (From Visual Inspection)

☐ Repairs req'd. beyond normal maint.
☑ No defects observed beyond normal maint.

check file 3B-1102

3B-608

Fredonia Reservoir

NY 749

DATE INSPECTED 10-19-77

BY KDH

Reinspected 10/4/79 K. Hemmer
R. McCarty

Spillway wall (Rt.) moved 6"
Remove trees, heavy storm damage
in downstream channel ⇒ homes
& bldgs undermined

New York State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233
Room 422

Robert F. Flacke,
Commissioner

October 15, 1979

Ms. Wanda Gustafson, Director
Chautauqua County Office of Civil
Defense
County Office Building
P.O. Box 183
Mayville, New York 14757

Re: Safety Inspection of
Chautauqua County Dams

Dear Wanda:

During the first week of October 1979, inspections of various dams were conducted at your request by Messrs. Kenneth Harmer and Robert McCarty of the DEC Dam Safety Section, and Mr. Charles Hagstrom your Deputy Director. A summary of the observations made during the inspections are as follows:

October 3, 1979

#4C-278 - Alleghany River Basin - Panama Dam - Reputed Owner: Gerry A. Green

The dam was reported to be overtopped during the September 14, 1979 storm; causing severe erosion of N.Y. Route #74, a section of the west embankment, and portions of the downstream channel. Modifications by NYS DOT in the alignment of Route #74 are blamed for the erosion. Ownership and liability will require further investigation. Future storms may initiate further erosion. We suggest this dam be monitored closely. This dam will receive a Phase I inspection this fall.

#2D-2691 - Alleghany River Basin - Jaquin's Pond Dam - Owner: Chautauqua County Federation of Sportsmen's Clubs, Inc.

The gates of this dam are open and no water is being impounded by the dam.

#2C-339 - Alleghany River Basin - Clymer Dam - Owner: Village of Clymer

The dam is in good condition.

#2C-859 - Lake Erie Basin - Findley Lake Dam - Owner: Village of Findley Lake

Concrete deterioration of the outlet structure was reported, but not observed. This structure will get a Phase I inspection this fall.

#3B-608 - Lake Erie Basin - Fredonia Reservoir Dam - Owner: Village of Fredonia

The right spillway wall is eroded and has moved inward approximately 6 inches. The embankment is heavily vegetated and these trees must be cut. Severe erosion of the downstream channel was observed as a result of the September 14, 1979 storm. This dam will receive a Phase I inspection this fall.

#6D-516 - Lake Erie Basin - Smith Mills Reservoir Dam - Owner: Village of Silver Creek

Excessive erosion of the concrete apron and underlying bedrock resulted from the September 14, 1979 storm. The sliding resistance and stability of the dam are in question. In depth engineering studies will be required to assess the dam's safety. This dam will receive a Phase I inspection this fall.

#7B-3979 - Alleghany River Basin - Conewango Creek Site 9A Dam - Owner: Conewango Creek Watershed Commission

This dam could not be located. Later it was discovered that the location map was incorrect. This dam will be reinspected later this fall.

#7C-3743 - Alleghany River Basin - Conewango Creek Site 3 Dam - Owner: Same as above

This dam is in excellent condition. Evidence of flow was noted in the auxiliary spillway adjacent to the dam. This condition is necessary for any storm in excess of the 100-year frequency. The adjacent landowner should not be permitted access to the auxiliary spillway, because extensive erosion will and has resulted. The owner is aware of this condition and will initiate the appropriate repairs.

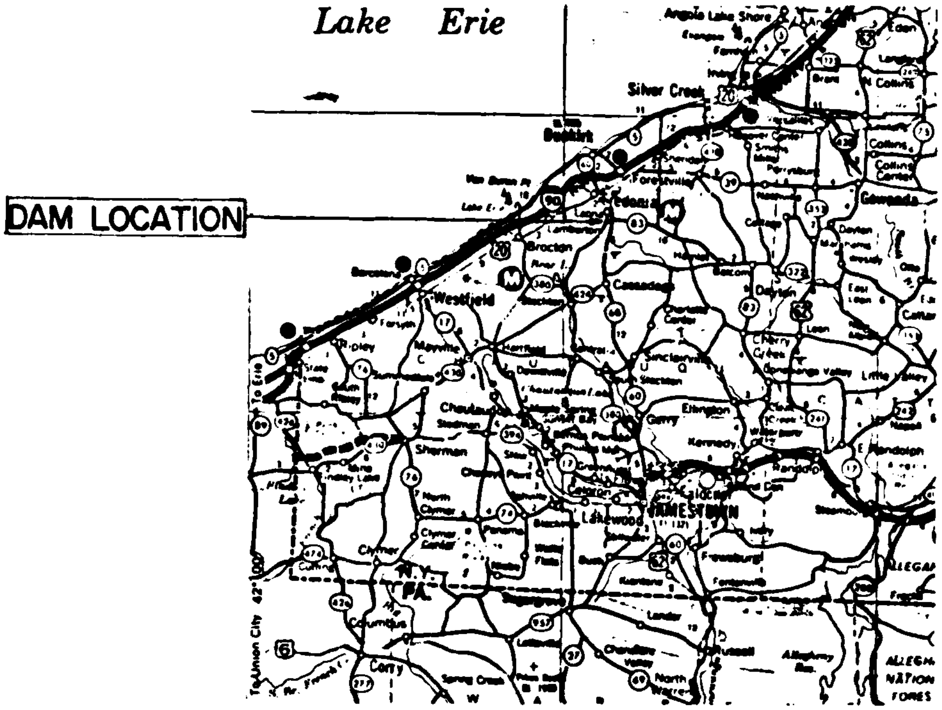
October 5, 1979

#4A-2776 - Alleghany River Basin - Hall Dam - Owner: Helen M. Hall

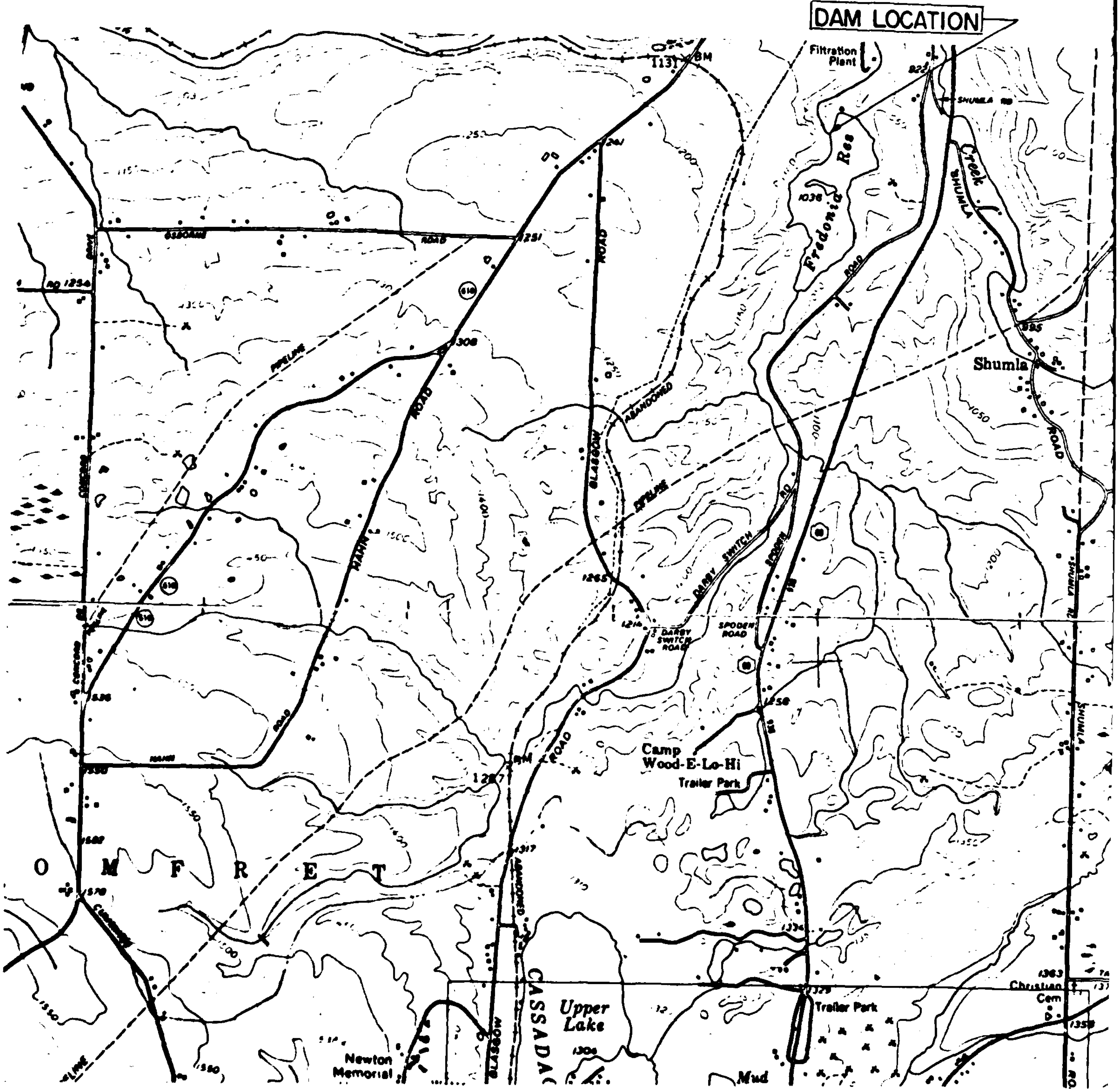
Serious erosion of the soil downstream of the auxiliary spillway was observed due to the September 14, 1979 storm, and it appears that the dam was nearly overtopped. Stoplogs should be removed immediately and be maintained that way until the auxiliary spillway is repaired and additional spillway capacity is achieved. This may be accomplished at the left abutment in the level area adjacent to the dam. This auxiliary spillway could be constructed with the use of a bulldozer and further erosion problems may be avoided.

APPENDIX G

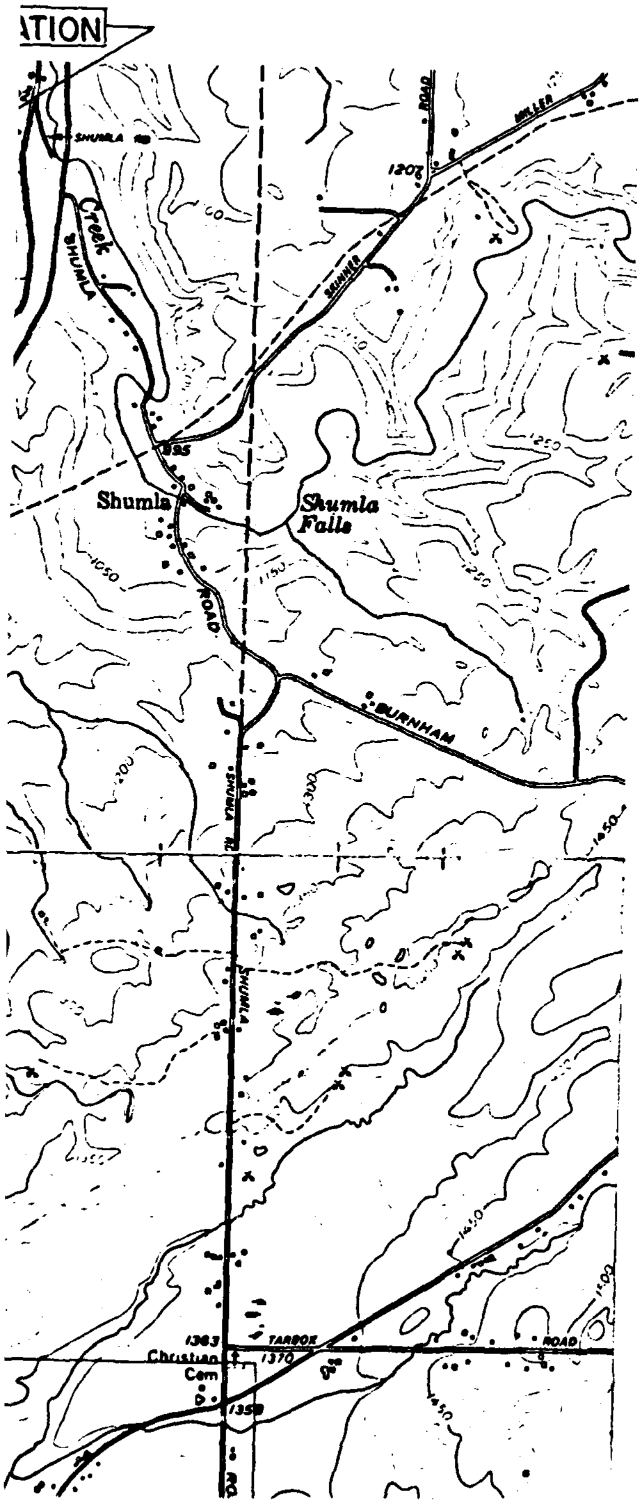
DRAWINGS


Lake Erie
DAM LOCATION
Silver Creek
Dunkirk
Fredonia
Forestville
Brocton
Westfield
Ripley
Mayville
Chautauqua
Sherman
Cassadaga
Sinclairville
Gerry
Ellington
Cherry Creek
Dayton
Gowanda
Jamestown
Lakewood
Falconer
Frewsburg
Clymer
Panama
Corry
Columbus
N.Y.
PA.
Randolph
To Erie
To Union City

VICINITY MAP
FREDONIA RESERVOIR
I.D. NO. N.Y. 749


DAM LOCATION
Filtration Plant
Fredonia Res
Shumla Creek
SHUMLA RD
SHUMLA ROAD
Shumla
OSBORNE ROAD
GLASGOW ROAD
HAHN ROAD
PIPELINE
ABANDONED
DARBY SWITCH RD
DARBY SWITCH ROAD
SPODEN ROAD
CONCORD
Camp Wood-E-Lo-Hi
Trailer Park
POMFRET
CASSADAGA
Upper Lake
Newton Memorial
Mud
Christian Cem
BM
1131
1251
1261
1308
1265
1216
1258
1287
1317
1334
1329
1363
1359
1036
1580
1586
1570
1550
1250
1200
1150
1100
1050
1000
922
995
1306
616
60

1


ATION
SHUMLA RD
Creek
SHUMLA
ROAD
MILLER
1207
SKINNER
1250
935
Shumla
Shumla Falls
1050
1150
ROAD
BURNHAM
1200
1300
SHUMLA RD
1450
SHUMLA
1450
1500
1363
TARBOX
ROAD
Christian
Cem
1370
1358
1450

TOPOGRAPHIC MAP
FREDONIA RESERVOIR
I.D. NO. N.Y. 749

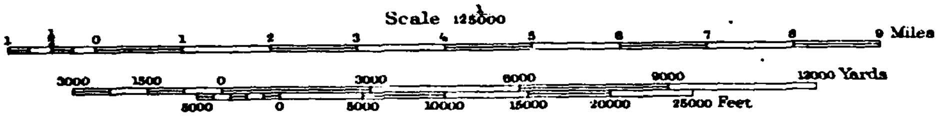
2

1

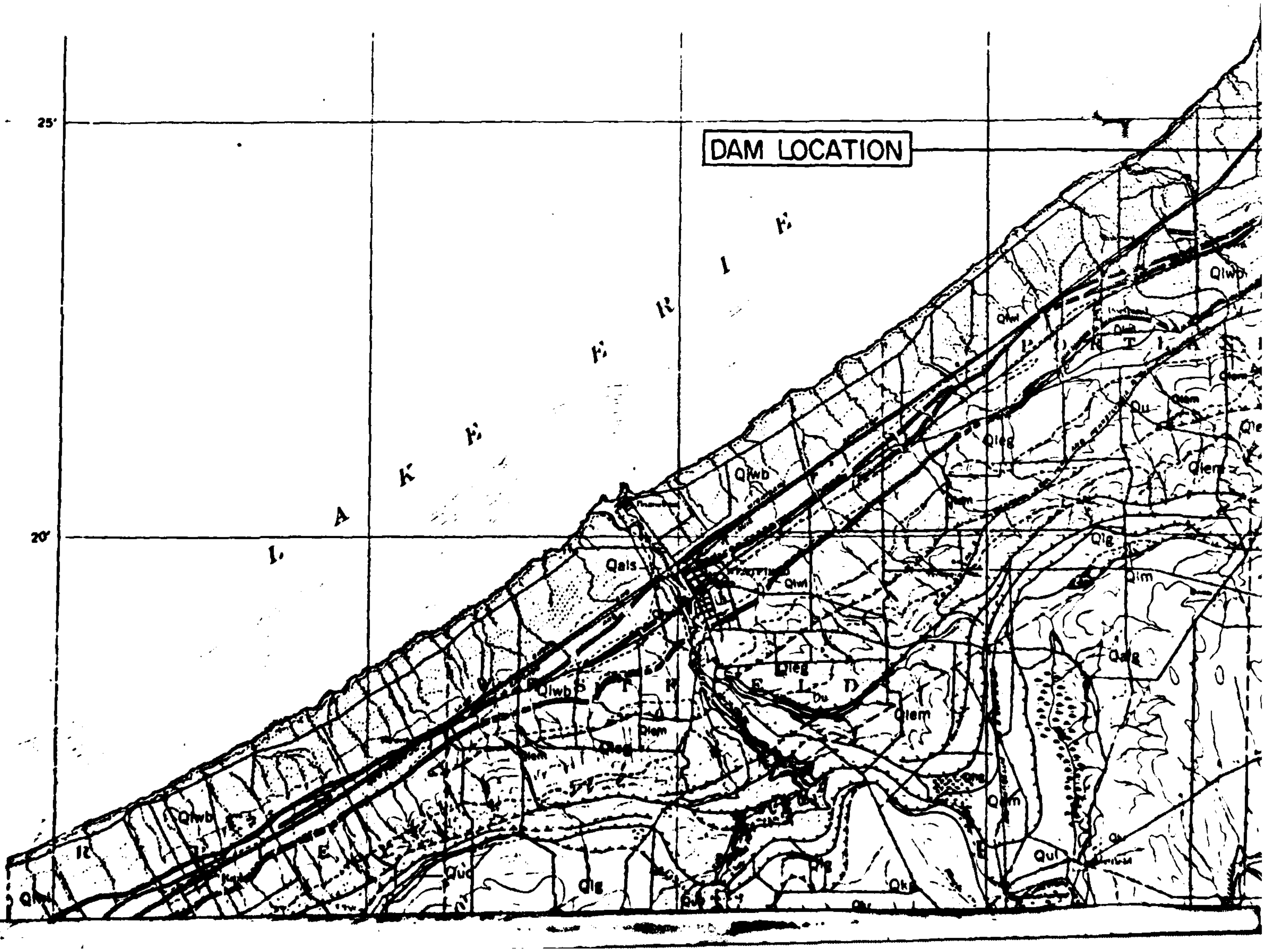
PLEISTOCENE GEOLOGY OF
CHAUTAUQUA COUNTY, NEW YORK

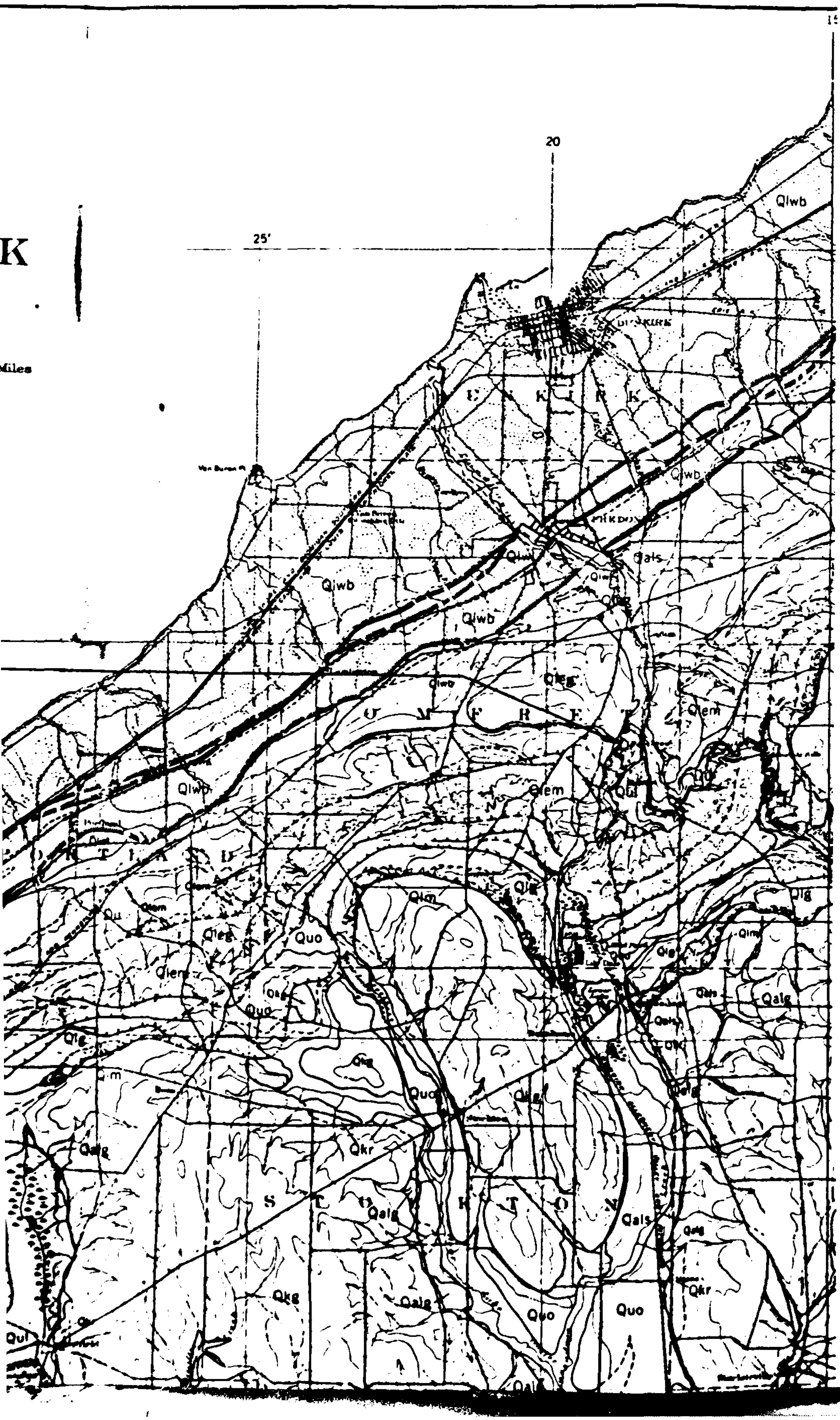
By

E. H. MULLER


Scale 1/125000
1 ½ 0 1 2 3 4 5 6 7 8 9 Miles
3000 1500 0 3000 6000 9000 12000 Yards
5000 0 5000 10000 15000 20000 25000 Feet

1964


DAM LOCATION
25'
20'
L A K E E R I E
Qlwb
Qals
Qlwl
Qleg
Qlem
Qlg
Qlm
Qalg
Qu


K
Miles
25'
20
15
Qlwb
DUNKIRK
D U N K I R K
Van Buren Pt.
FREDONIA
Qlwb
Qlwb
Qals
Qlwb
Qlwb
Qkg
Qlem
P O M F R E T
Qlem
Qlg
P O R T L A N D
Qlem
Qu
Qlem
Qlg
Quo
Qlem
Quo
Qlm
Qlg
Qlg
Qlm
Qals
Qalg
Qlg
Qkg
Quo
Qalg
Qm
Qalg
Qkr
S T O C K T O N
Qalg
Qals
Qalg
Qkg
Qalg
Quo
Quo
Qkr
Qul
Qal

Qhg

Hiram (?) ground moraine

Lavery glaciation

Qlm

End moraine

Qlg

Ground moraine

Kent glaciation

Qkm

End moraine

Qkg

Ground moraine

Qkr

Findley and Clymer recessional moraines and stratified drift

Qrm

Residual mantle and congeliturbate

Undifferentiated as to age

Quo

Outwash

Qul

Proglacial and post-glacial lake sediments

Qud

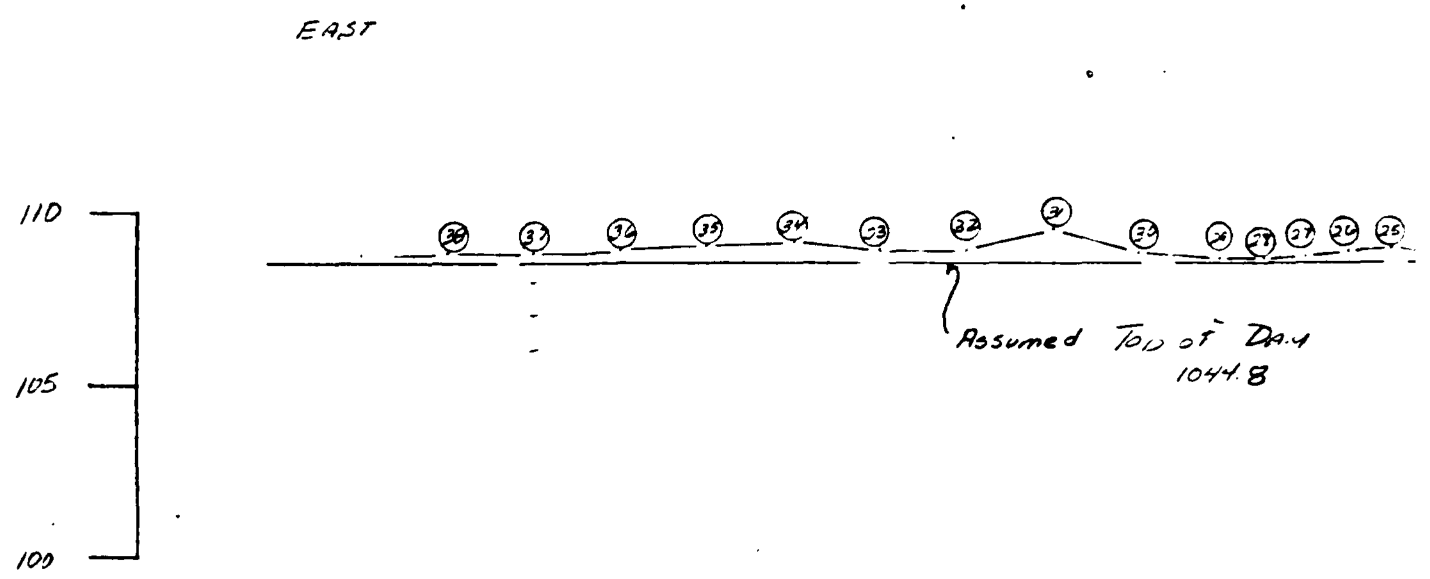
Attenuated drift

Qu

Less than 3 feet of drift over bedrock

BY STG DATE [illegible] SUBJECT [illegible]
View looking Upstream
CHKD. BY DATE
SHEET NO. OF
JOB NO. E-90-1

Survey of Spillway Crest & East Embankment
6/26/80 by Thomsen Associates


EAST
110
105
100
38
37
36
35
34
33
32
31
30
29
28
27
26
25
Assumed Top of Dam
1044.8

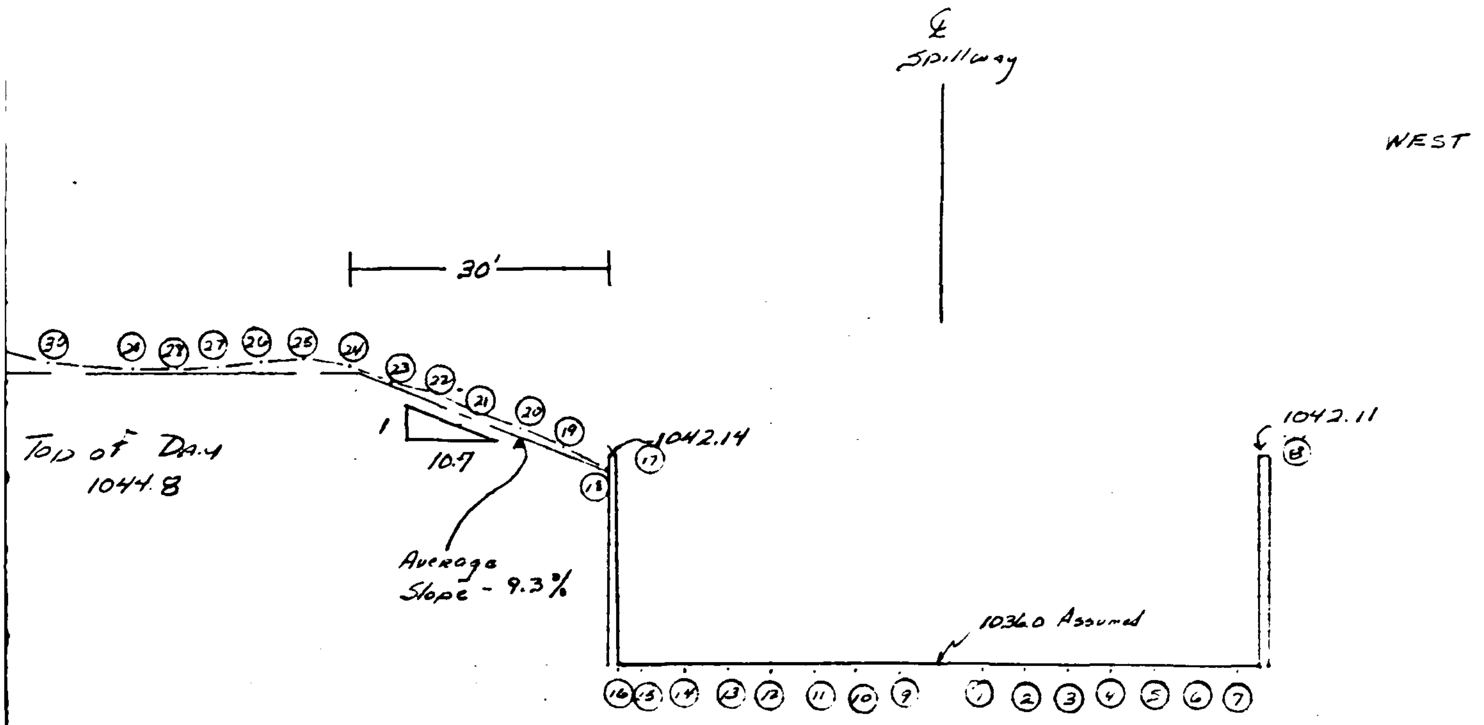
○ — Level Loop Shot No.

Shot No.	Elevation	Shot No.	Elevation
1	1036.03	21	1043.39
2	1036.05	22	1043.90
3	1036 07	23	1044.22
4	1036 06	24	1044.70
5	1036.04	25	1044 87
6	1036.06	26	1044 79
7	1036.05	27	1044.66
8	1042 11	28	1044.58
9	1036.05	29	1044 81
10	1036.07	30	1045 51
11	1036.09	31	1044 91
12	1036 07	32	1044.94
13	1036 05	33	1045.08
14	1036.04	34	1045 01
15	1036.01	35	1044.87
16	1036.04	36	1044.78
17	1042.14	37	1044 82
18	1041 70	38	1044 75
19	1042 40		
20	1042.93		

Average
Assumed

OF 2
k-1

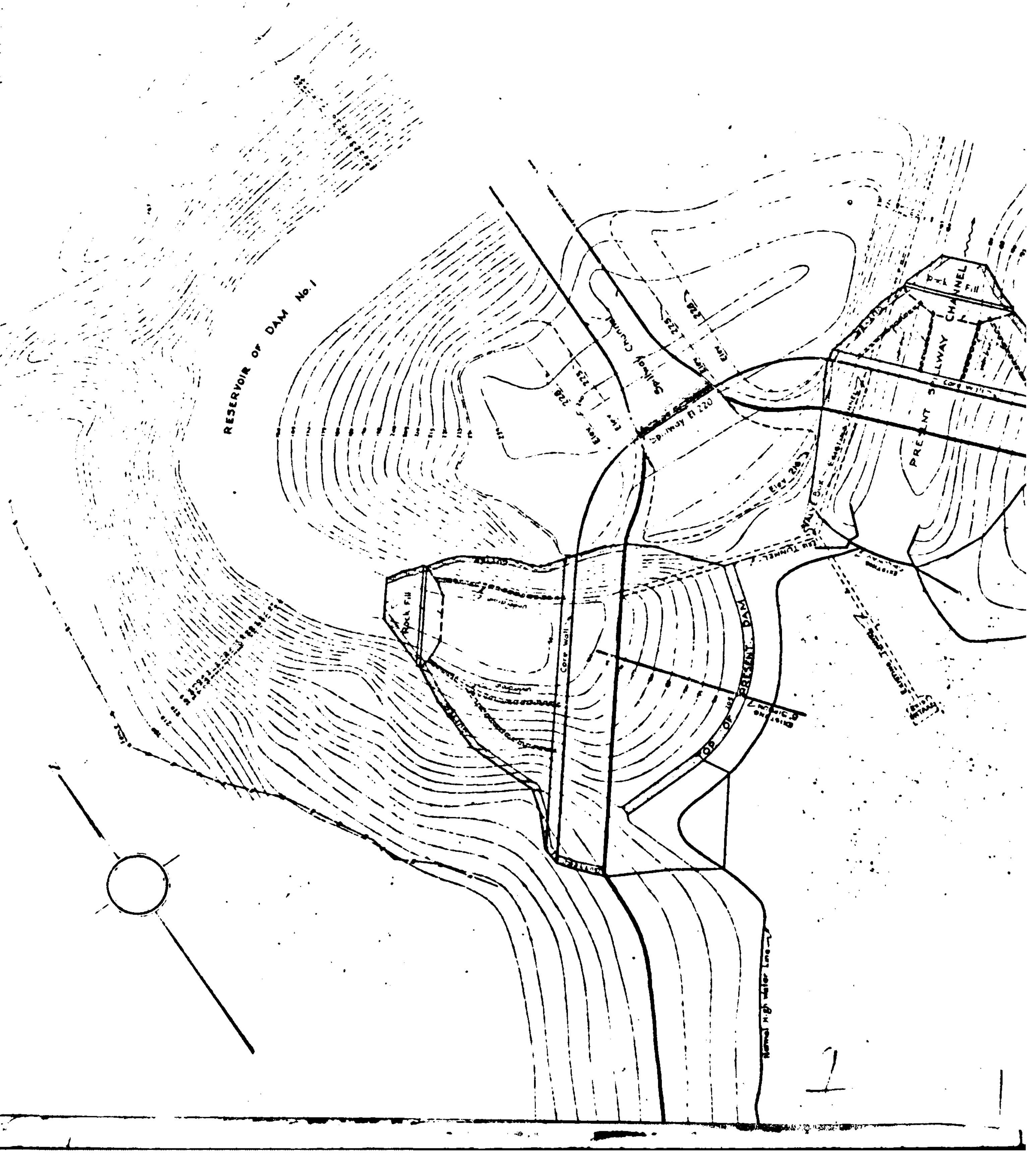
ast Embankment Crest
Associates

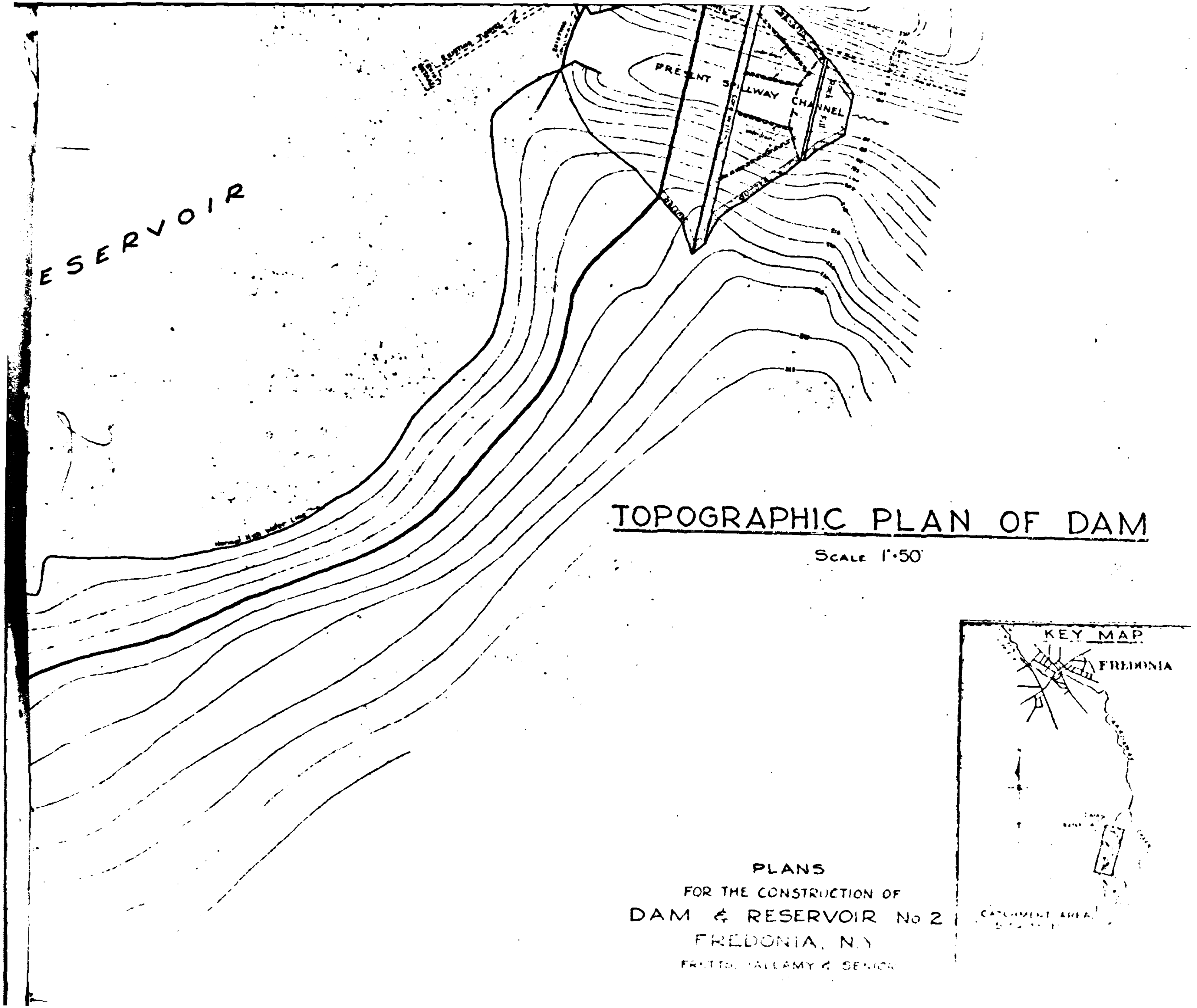

℄
Spillway
WEST
30'
33
28
27
27
26
25
24
23
22
21
20
19
18
17
Top of Dam
1044.8
1
10.7
Average
Slope - 9.3%
1042.14
1042.11
8
1036.0 Assumed
16
15
14
13
12
11
10
9
1
2
3
4
5
6
7

vation
43.39
3.90
44.22
44.70
4487
44 79
44.66
44.58
44 81
45.51
44 91
44.94
45.08
45 01
44.87
44.78
4482
4 75

Average 1044.87
Assumed TOP OF DAM
- 1044.80

Vertical Scale: 1" = 5.0'
Horizontal Scale: 1" = 20.0'
Datum: ℄ Spillway crest
Assumed Elevation = 1036.0

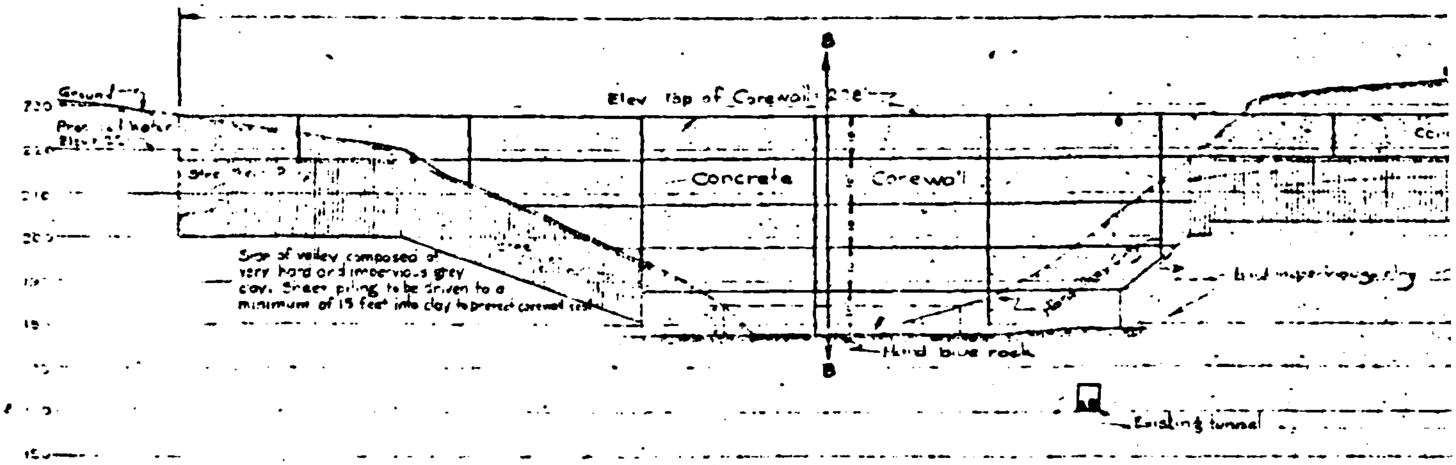

RESERVOIR OF DAM No.1
Spillway Channel
Elev 228
Elev 223
Elev 228
Elev 223
Spillway El 220
Elev 216
PRESENT SPILLWAY CHANNEL
R-L Fill
Core wall
Rock Fill
Core Wall
TOP OF PRESENT DAM
Normal High Water Line


ESERVOIR
PRESENT SPILLWAY CHANNEL
Rock Fill
KEY MAP
FREDONIA
CATCHMENT AREA

TOPOGRAPHIC PLAN OF DAM

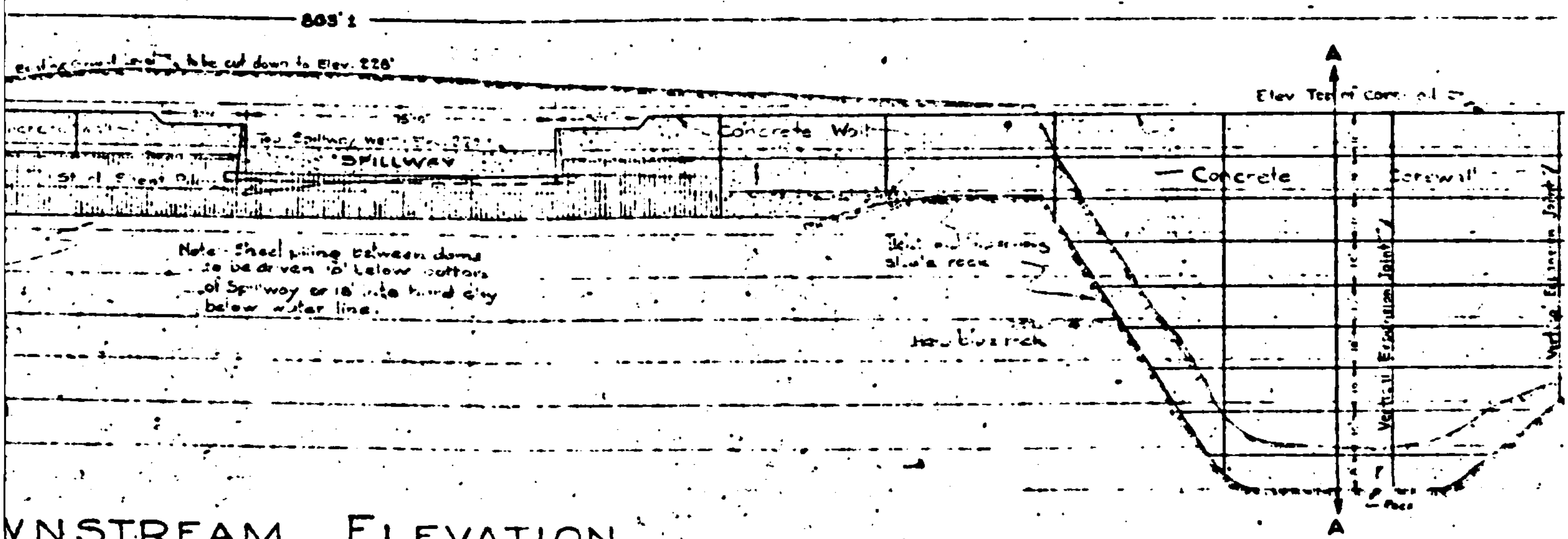
Scale 1"-50'

PLANS
FOR THE CONSTRUCTION OF
DAM & RESERVOIR No 2
FREDONIA, N.Y
FRITTS, TALLAMY & SENIOR


Ground line
Present water Elev
230
220
210
200
150
Sheet piling
Slope of valley composed of very hard and impervious grey clay. Sheet piling to be driven to a minimum of 15 feet into clay to protect corewall
Elev. top of Corewall
B
Concrete
Corewall
Hard blue rock
B
Hard impervious clay
Existing tunnel

Dow

I

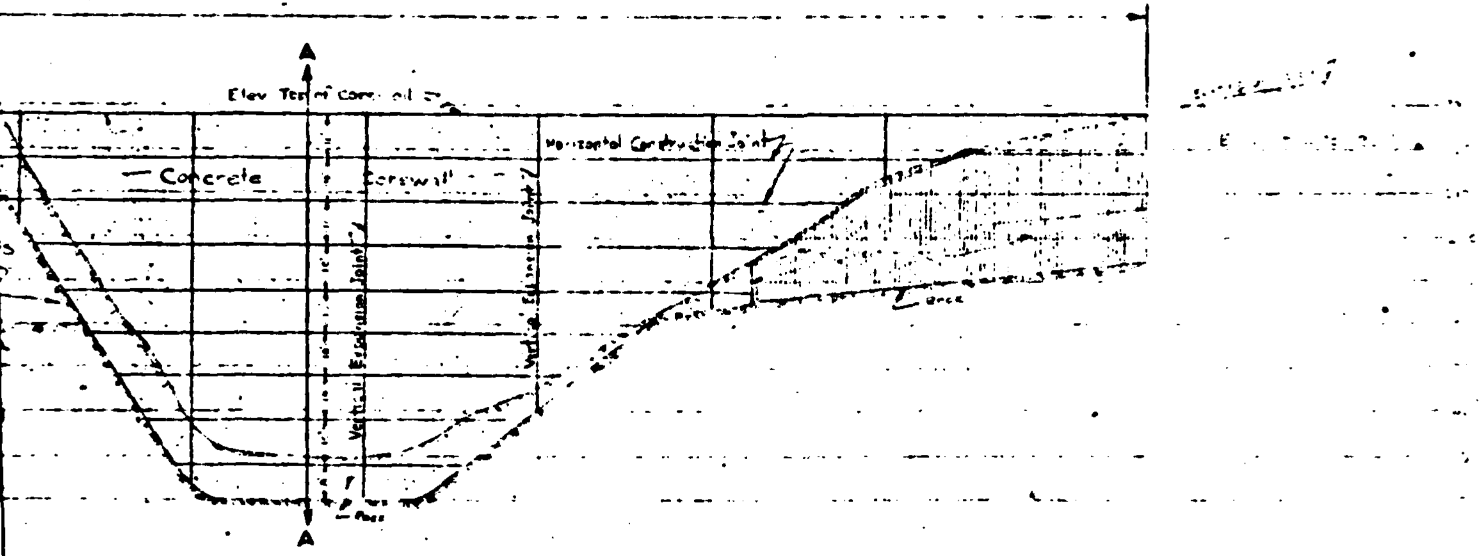

803' ±
Existing ground level to be cut down to Elev. 228'
75'0"
Top Spillway weir Elev. 228'
SPILLWAY
Concrete Wall
Steel Sheet Piling
Concrete Wall
Note - Steel piling between dams to be driven 10' below bottom of Spillway or 18' into hard clay below water line.
Elev. Top of Core wall
A
Concrete
Corewall
Vertical Expansion Joint
Vertical Expansion Joint
Soft and Yielding shale rock
Hard blue rock
Rock
A

VNSTREAM ELEVATION

SCALE 1"=20'

D

2

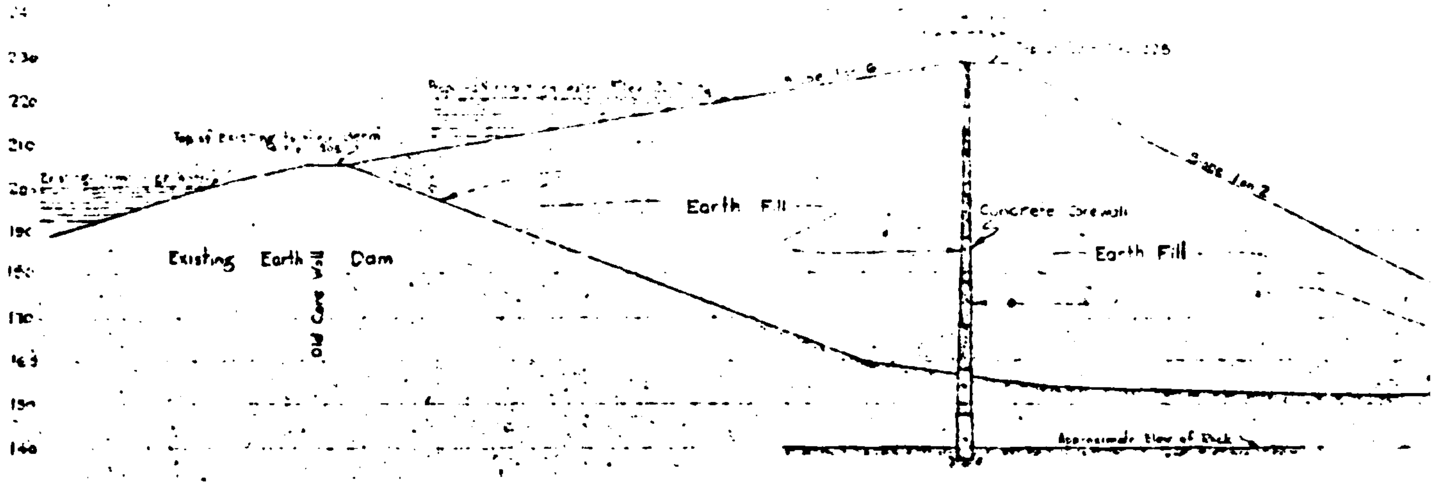

A
Elev Top of Corewall
Concrete Corewall
Horizontal Construction Joint
Vertical Expansion Joint
Vertical Expansion Joint
Rock
Rock
A

PLANS
FOR THE CONSTRUCTION OF
DAM AND RESERVOIR No 2
FREDONIA, N. Y.

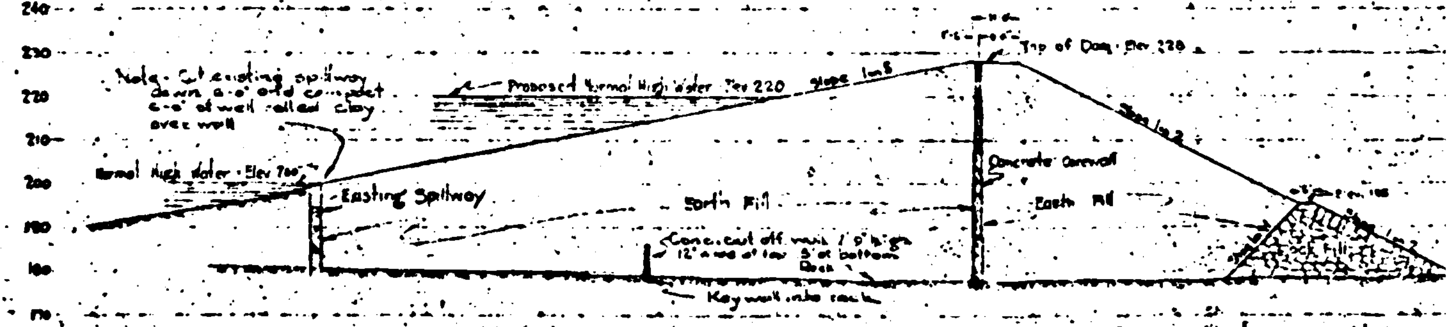
FRETTS, TALLAMY & SENIOR
CONSULTING ENGINEERS
WILLIAMSVILLE, N.Y.

OCTOBER 1933

3


230
220
210
200
190
180
170
160
150
140
Top of Existing Spillway Berm
Existing Earth Dam
Old Core Wall
Earth Fill
Slope 1 on 6
Top of Dam Elev 228
Slope 1 on 2
Concrete Corewall
Earth Fill
Approximate Elev of Rock

SECTION A-A

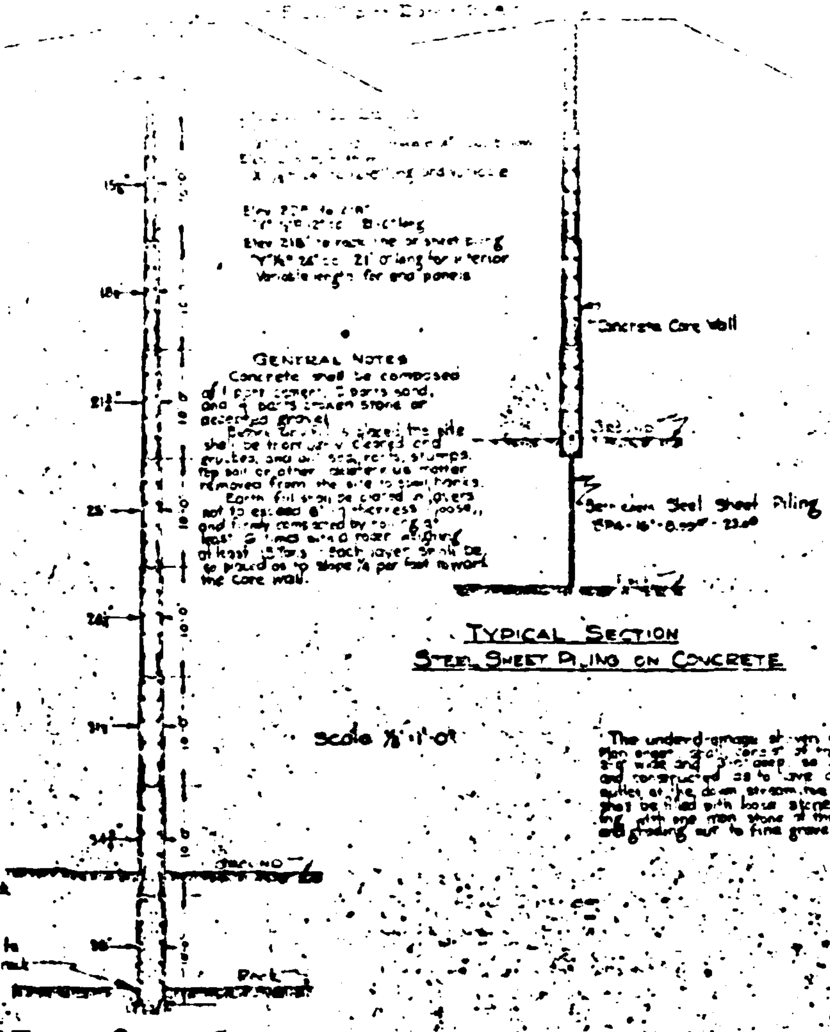

240
230
220
210
200
190
180
170
Note - Cut existing spillway down 6-0" and compact 6-0" of well rolled clay over wall
Normal High Water - Elev 200
Existing Spillway
Proposed Normal High Water Elev 220
Slope 1 on 8
Top of Dam - Elev 228
Slope 1 on 2
Earth Fill
Concrete Corewall
Earth Fill
Conc. cut off wall 1'-9" high 12" wide at top 3' at bottom
Rock
Key wall into rock
Rock Fill
Slope 1 on 2

SECTION B-B

1

Elev 170
Rock Fill

- At points where it is impossible to roll, the fill shall be well tamped with heavy tampers to the same density as if rolled.
- On sloping ground successive layers should be stepped into original surface.
- Before fresh fill is placed on any compacted layer, the surface of the latter shall be sufficiently rolled to bond the two layers into one homogeneous mass.


Elev 218' to rock line or sheet piling
"Y"K" 24" c.c. 21' 0" long for interior
Variable length for end panels
Concrete Core Wall
Ground
Bethlehem Steel Sheet Piling
Ground
Rock

GENERAL NOTES

Concrete shall be composed of 1 part cement, 2 parts sand, and 4 parts broken stone or screened gravel.

Before Earth fill is placed the site shall be thoroughly cleared and grubbed, and all sod, roots, stumps, top soil or other deleterious matter removed from the site to spoil banks.

Earth fill shall be placed in layers not to exceed 6" in thickness (loose), and firmly compacted by rolling at least 6 times with a roller weighing at least 15 tons. Each layer shall be so placed as to slope ¼ per foot toward the core wall.

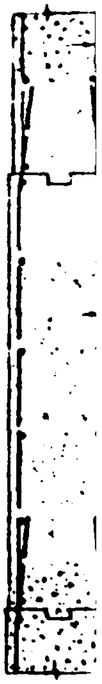
TYPICAL SECTION
STEEL SHEET PILING ON CONCRETE

Scale ⅛"=1'-0"

The underdrainage shown on the Plan shall consist of trenches 2'-0" wide and 3'-0" deep, so located and constructed as to give a free outlet at the down stream toe. Trench shall be filled with loose stone, starting with one man stone at the bottom and grading out to fine gravel at the top.

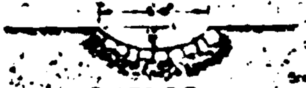
Note: Portion of core wall in rock not to be formed but poured in rock trench as excavated. Trench to be of sufficient depth to ensure good anchorage in solid rock.

TYPICAL CONCRETE SECTION



PLANS
FOR THE CONSTRUCTION OF
DAM & RESERVOIR No. 2
FREDONIA, N.Y.

FRETTS, TALLAMY & SENIOR
CONSULTING ENGINEERS
WILLIAMSVILLE N.Y.
OCTOBER 1936

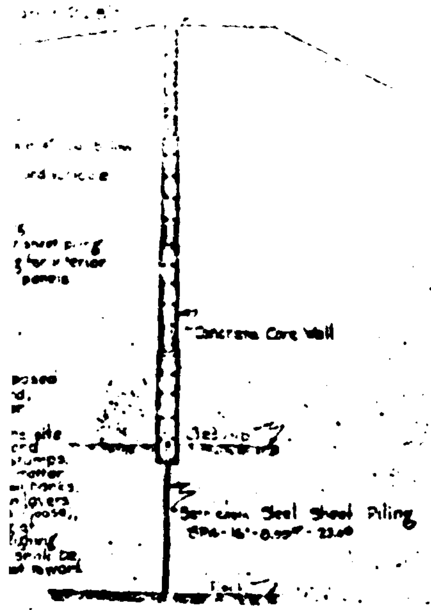


Scale ½"=1'-0"

GUTTER

To be placed at junction of down stream face and original ground as shown on the Topographic Plan of Dam. Gutter to be original field stone 6" to 14" or cobbles set in a bed of broken slag or gravel and firmly grouted with 1:2 cement grout.

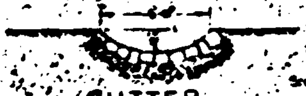
2


Concrete Core Wall
Steel Sheet Piling

TYPICAL SECTION
STEEL SHEET PILING ON CONCRETE

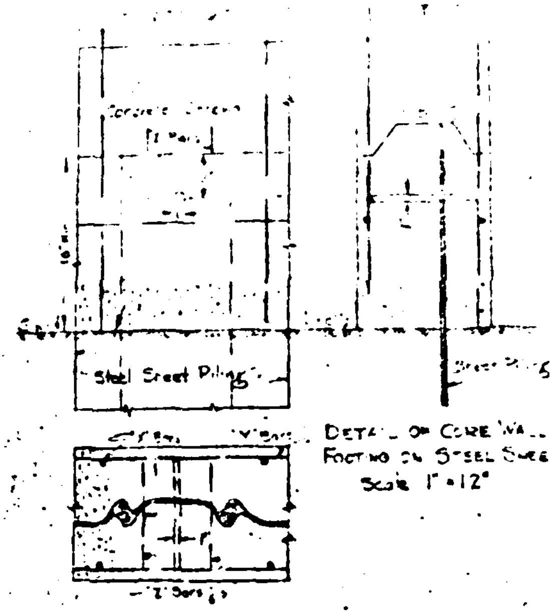
1'-0"

The underdrainage shown on the plan sheet shall consist of trenches 2'-0" wide and 3'-0" deep, so located and constructed as to have a free outlet at the down stream toe. Trench shall be filled with loose stone, starting with one man stone at the bottom and grading out to fine gravel at the top.

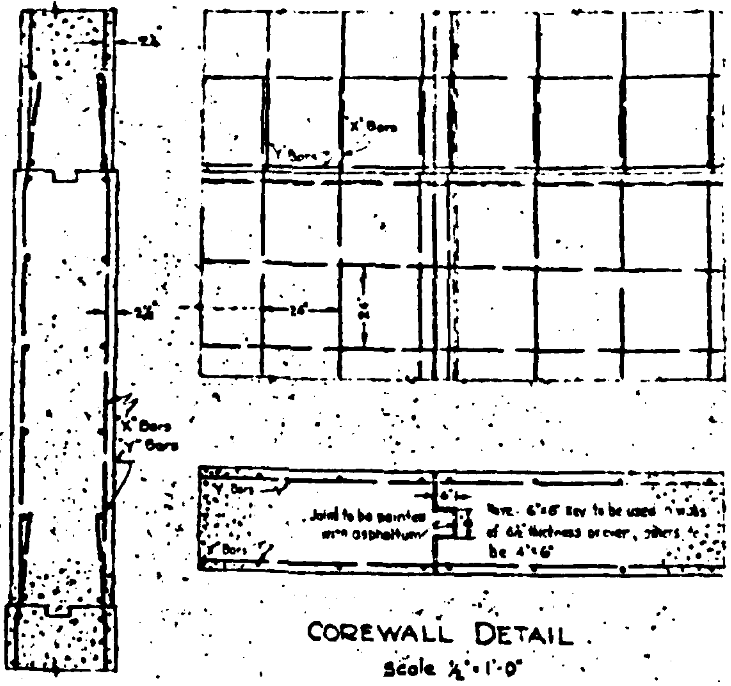

6'-0"
Scale ½"=1'-0"

GUTTER

To be placed at junction of down stream face and original ground as shown on the Topographic Plan of Dam. Gutter to be original field stone 6"x6"x4" or over, set in bed of cinders, slag or gravel and firmly grouted with 1:2 cement grout.


Concrete Corewall
Steel Sheet Piling
Steel Sheet Piling
X Bars
Y Bars
Z Bars

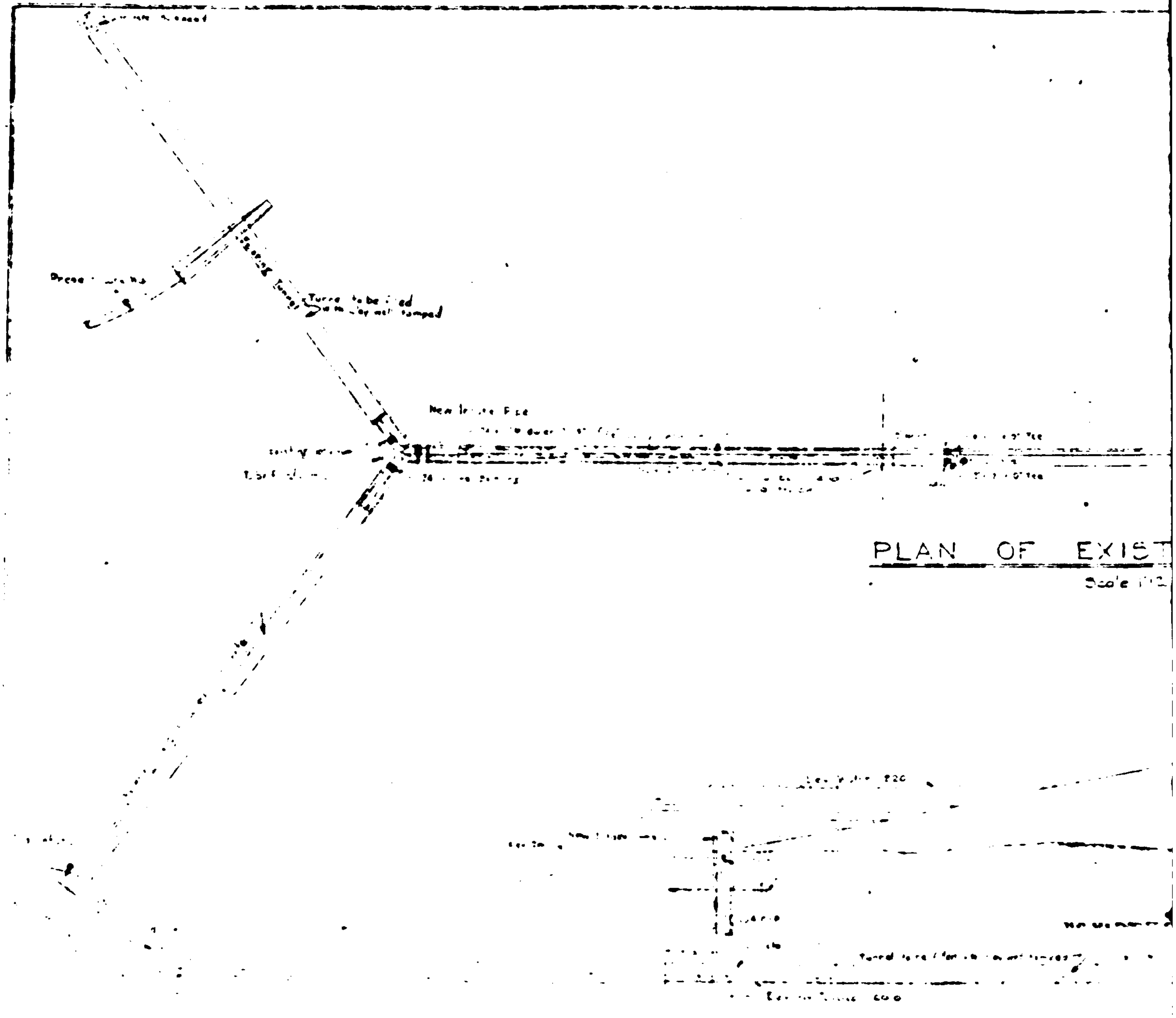
DETAIL OF CORE WALL
FOOTING ON STEEL SHEET PILING
Scale 1"=12"


2¼"
2¼"
X Bars
Y Bars
X Bars
Y Bars
24"
Y Bars
Y Bars
Joint to be painted with asphaltum
6"

Note. 6"x6" key to be used in walls of 6¼" thickness or over, others to be 4"x6"

CORE WALL DETAIL
Scale ¼"=1'-0"

13

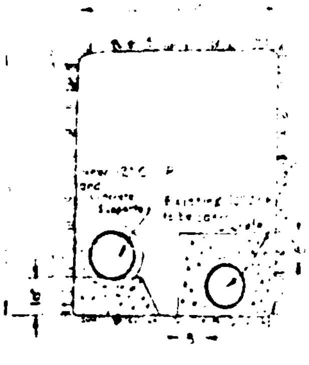

Present ...
Trench to be filled with clay well tamped
New Iron Pipe

PLAN OF EXIST

Scale 1"=2

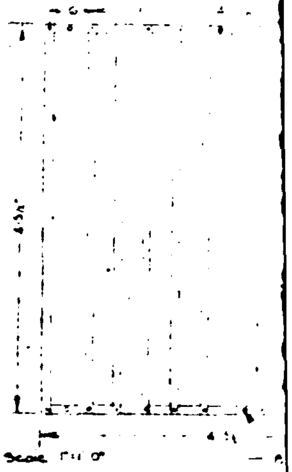
SECTION THROU

1



SECTION THRU TUNNEL

Scale ½

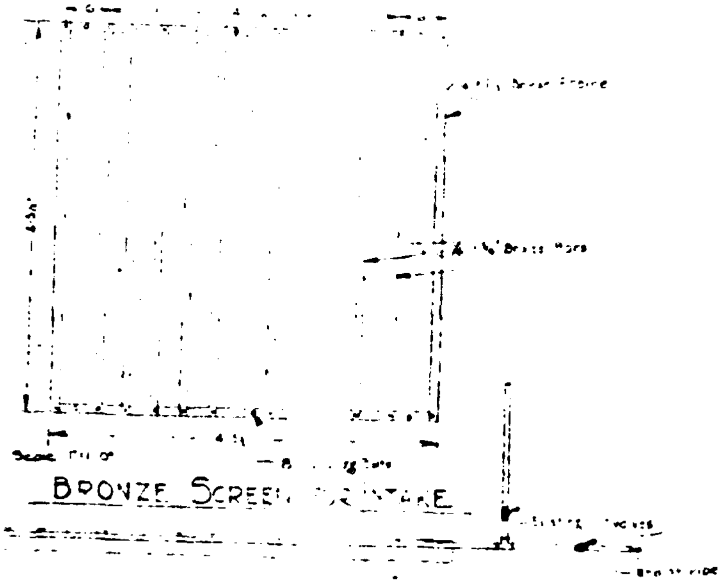


BRONZE SCREE

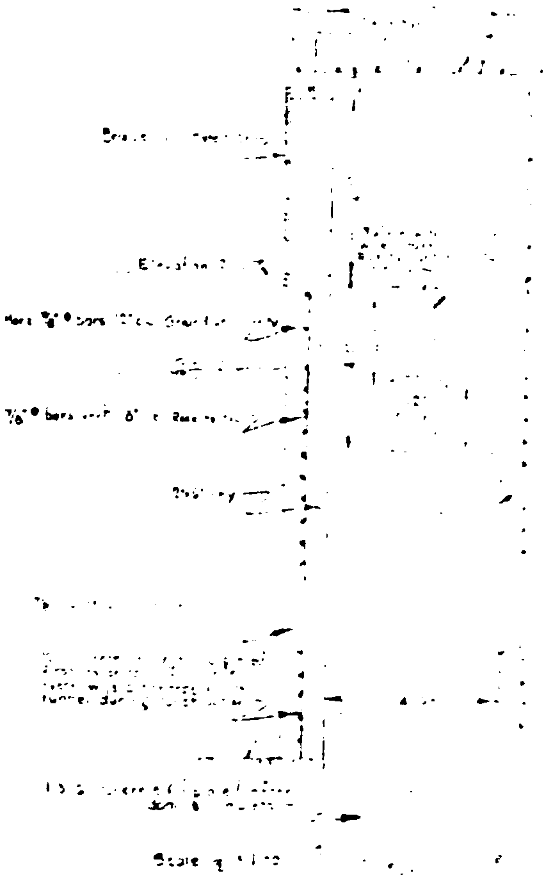
ISTING TUNNEL

UCH EXISTING TUNNEL

2

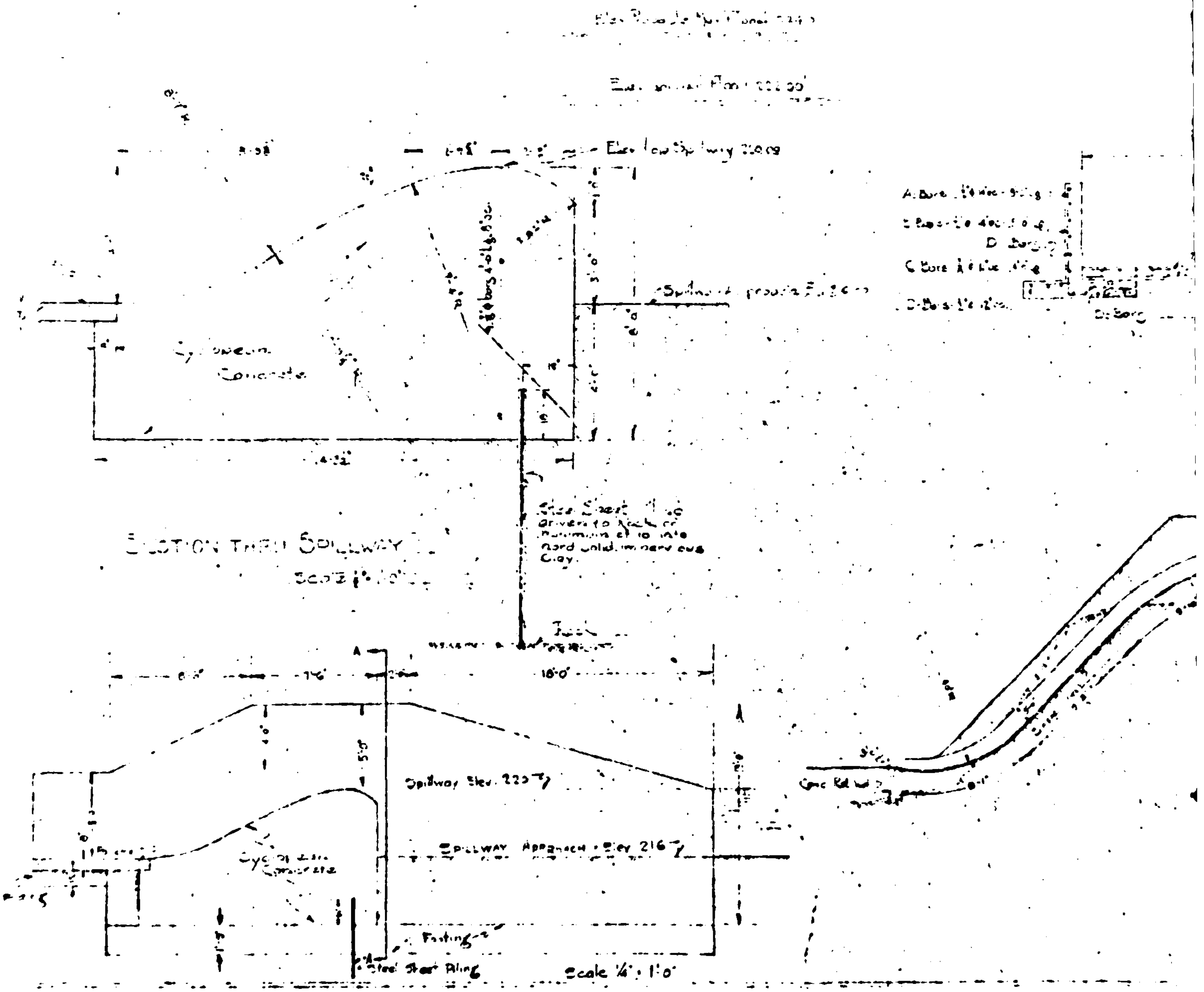

Brass Frame
Brass Plate
4'-3½"
Scale
Existing Invert
Drain Pipe

BRONZE SCREEN FOR INTAKE

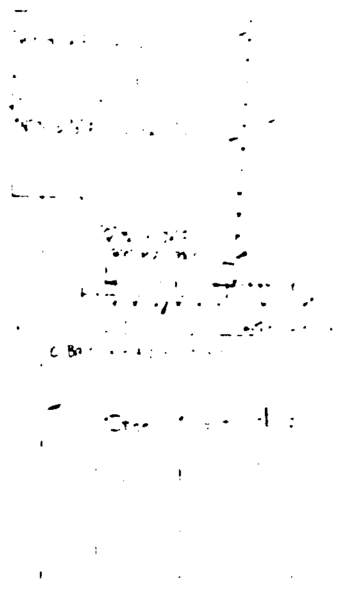

Brass Screen
Elevation
⅞" bars
Scale

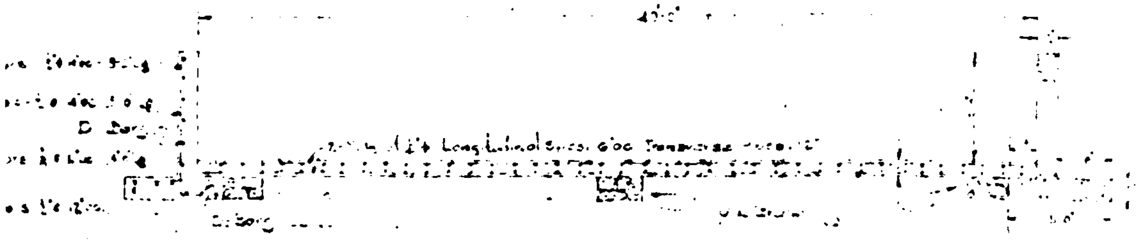
CROSS SECTION

1 3


Elev. Top of Spillway 220.09
Spillway Approach
Cyclopean Concrete
Steel Sheet Piling driven to Rock or minimum of 10 into hard solid impervious Clay.
18"
14'-2"
8'-5"
18'-0"
7'-6"
4'-0"
5'-0"
Spillway Elev. 220
Spillway Approach Elev. 216
Cyclopean Concrete
Footing
Steel Sheet Piling
Scale ¼" = 1'-0"
A
A Bore
D Bore
C Bore
D Bore

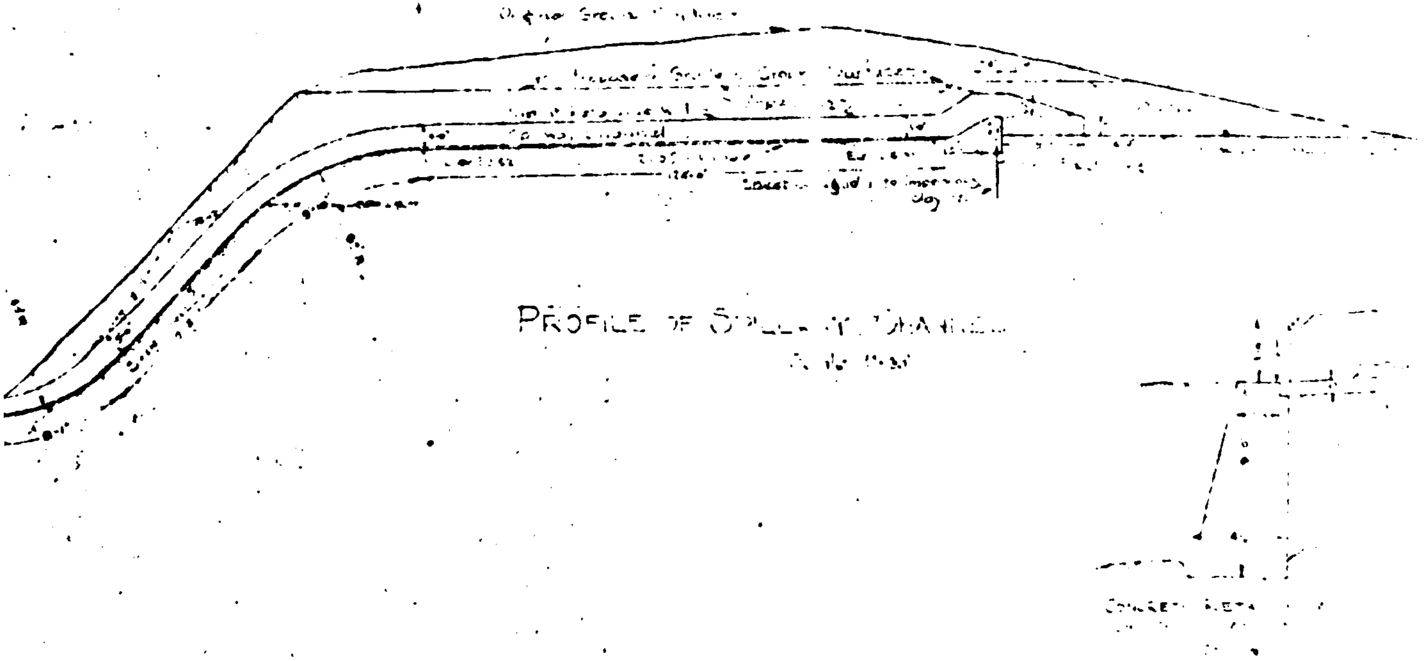
SECTION THRU SPILLWAY





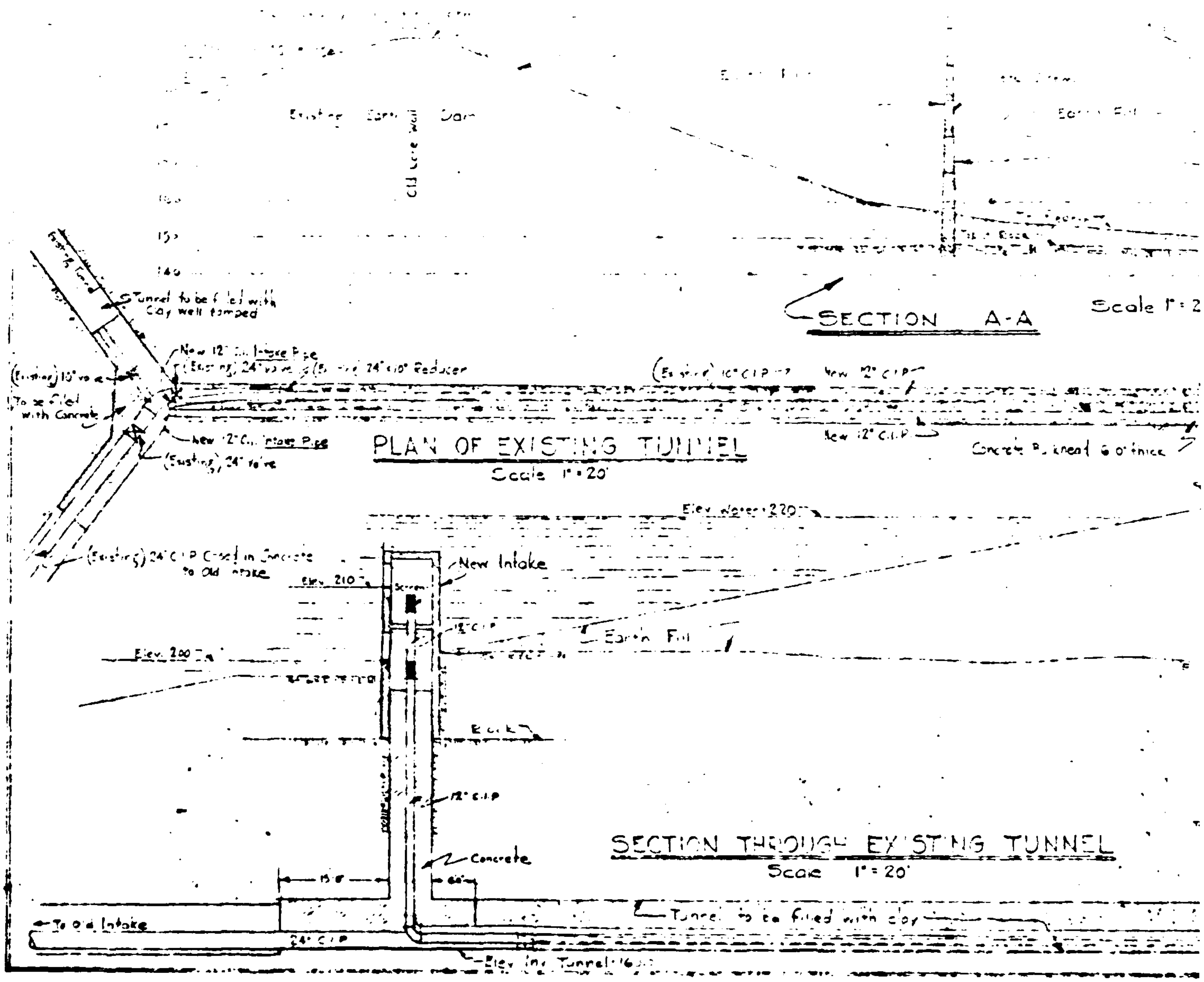
SECTION THRU SPILLWAY CHANNEL

Scale


Original Ground Surface
Spillway Channel
Concrete Retaining

PROFILE OF SPILLWAY CHANNEL

1 2



SECTION A-A

Scale 1" = 2

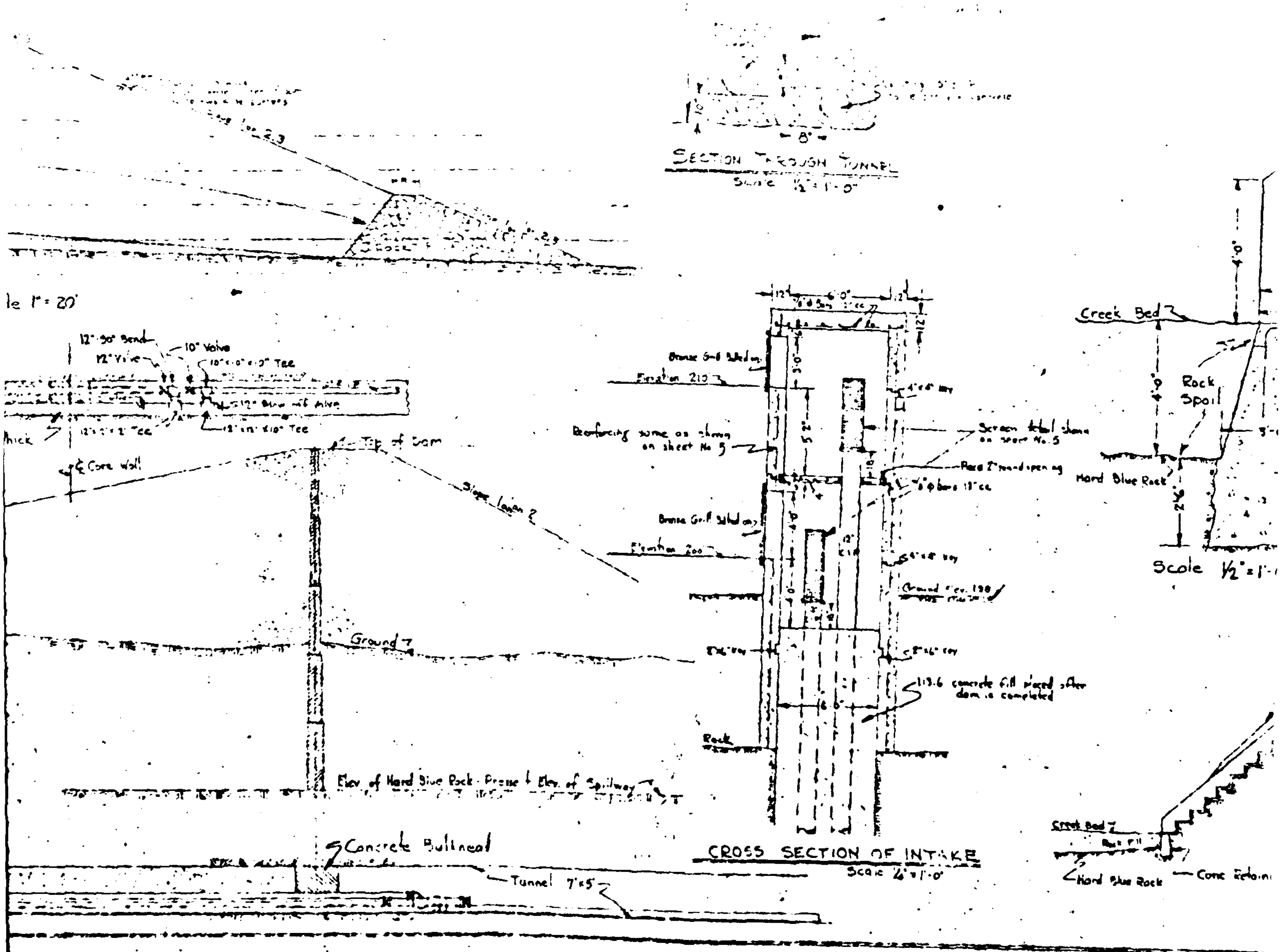
PLAN OF EXISTING TUNNEL

Scale 1" = 20'

SECTION THROUGH EXISTING TUNNEL

Scale 1" = 20'

Existing Earth Dam
Old Core Wall
Earth Fill
Earth Fill
150
140
Tunnel to be filled with Clay well tamped
New 12" C.I. Intake Pipe
(Existing) 24" valve
(Existing) 24" x 10" Reducer
(Existing) 10" valve
To be filled with Concrete
New 12" C.I. Intake Pipe
(Existing) 24" valve
(Existing) 24" C.I.P. Cased in Concrete to Old Intake
(Existing) 10" C.I.P.
New 12" C.I.P.
New 12" C.I.P.
Concrete Bulkhead 6.0' thick
Elev. Water 220
New Intake
Elev. 210
Screen
12" C.I.P.
Earth Fill
Elev. 200
Rock
12" C.I.P.
Concrete
15.0'
6.0'
To Old Intake
24" C.I.P.
Tunnel to be filled with clay
Elev. Inv. Tunnel 163



8"
le 1" = 20'
12" 90° Bend
12" Valve
10" Valve
12"x12"x12" Tee
12"x12"x10" Tee
hick
℄ Core Wall
Tip of Dam
Slope 1 on 2
Ground
Elev. of Hard Blue Rock
Elev. of Spillway
Concrete Bulkhead
Tunnel 7'x5'
6'-0"
Bronze Grill Sliding
Elevation 210
Reinforcing same as shown on sheet No. 5
Screen detail shown on sheet No. 5
Bronze Grill Sliding
Elevation 200
Ground Elev. 190
Rock
113.6 concrete fill placed after dam is completed
6'-0"
Creek Bed
Rock Spoil
Hard Blue Rock
Scale 1/2" = 1'-
Creek Bed
Rock Fill
Hard Blue Rock
Conc. Retain

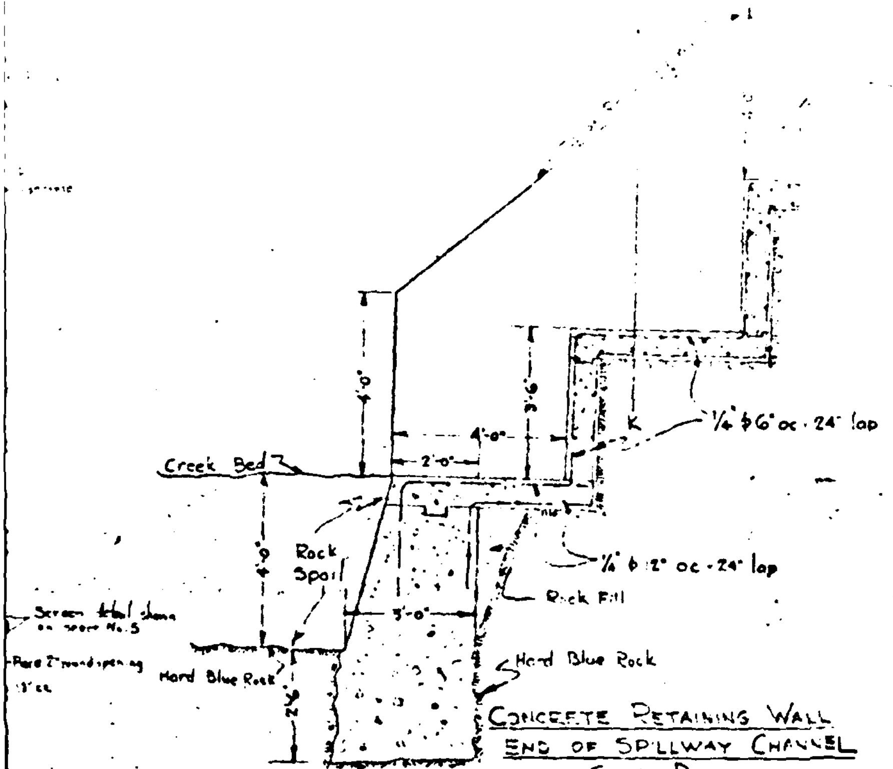
SECTION THROUGH TUNNEL

Scale 1/2" = 1'-0"

CROSS SECTION OF INTAKE

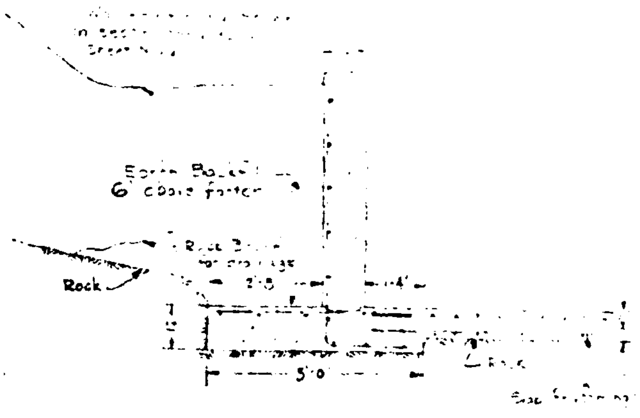
Scale 1/4" = 1'-0"

2

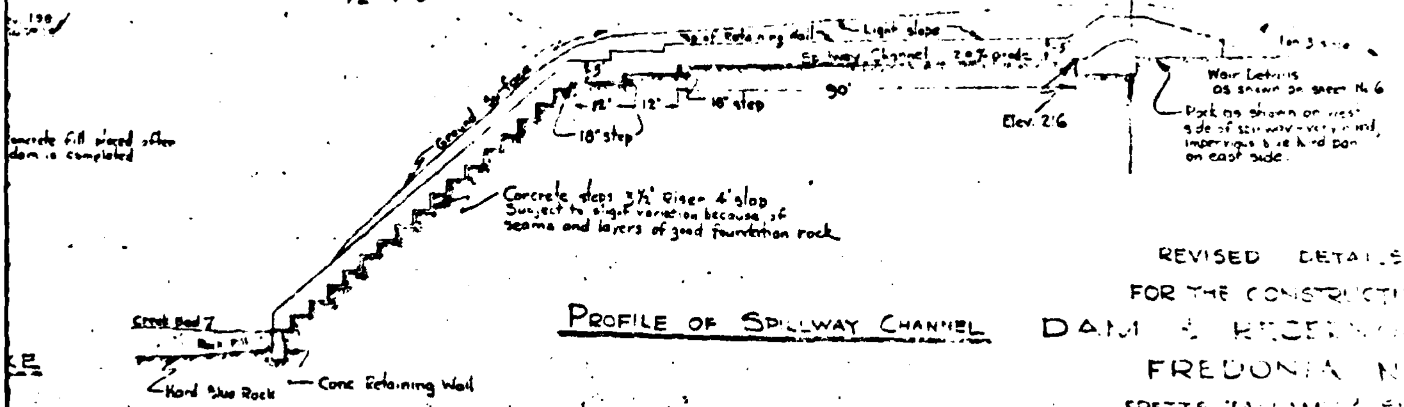

Creek Bed
4'-0"
2'-0"
K
¼" ϕ 6" oc - 24" lap
¼" ϕ 12" oc - 24" lap
Rock Spoil
Rock Fill
3'-0"
Hard Blue Rock
Hard Blue Rock
Screen detail shown on sheet No. 5
Pipe 2" round opening 12" cc

CONCRETE RETAINING WALL
END OF SPILLWAY CHANNEL
AND STEP DETAILS

Scale ½" = 1'-0"


Earth Bouquet
6" coarse filter
Rock
2'-6"
4'
5'-0"

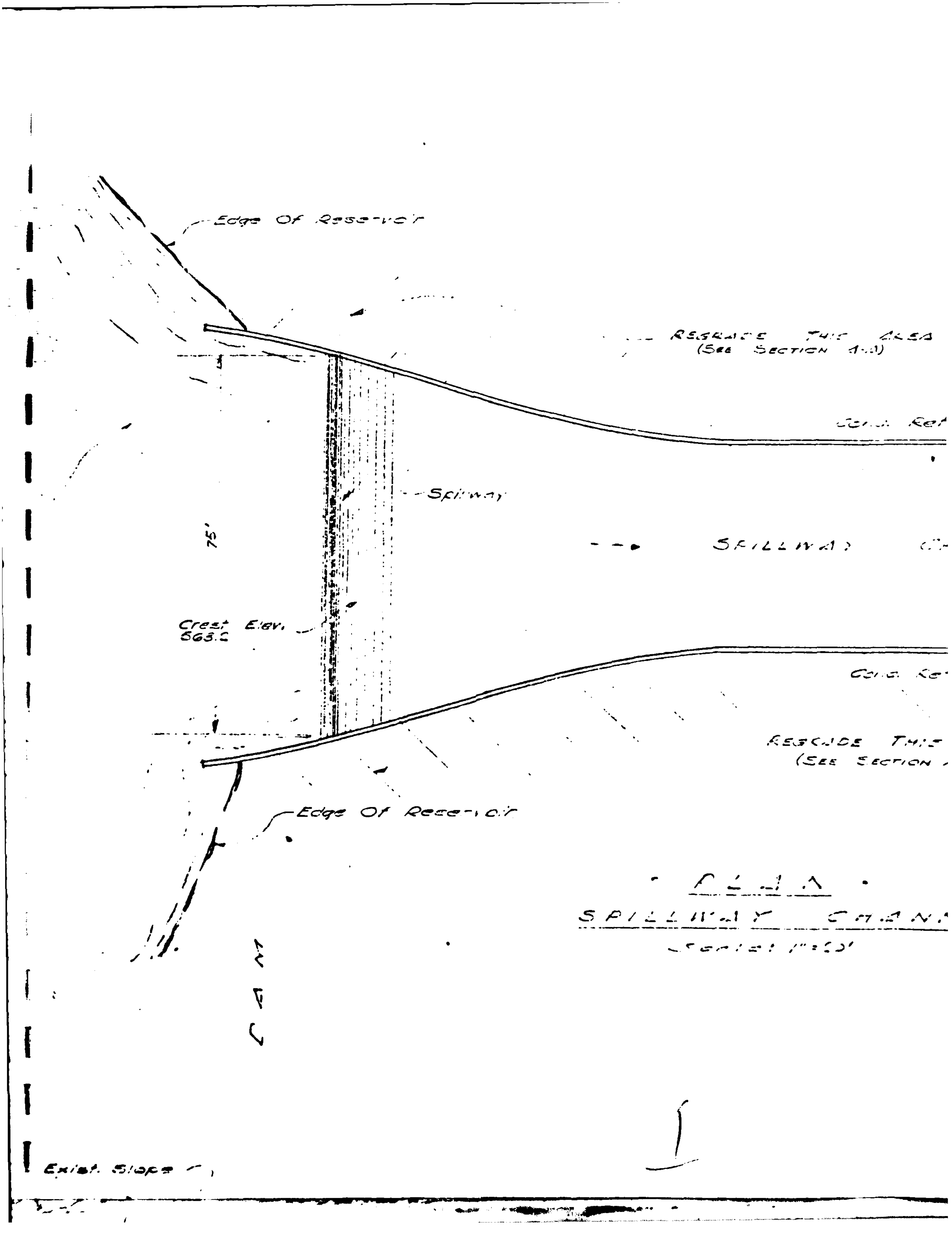
SECTION K - K
Scale ½" = 1'-0"


℄ of Corewall
Top of Retaining Wall
Light slope
Spillway Channel 2.0% grade
Ground surface
18" step
12"
18" step
90'
Elev. 2'6
Weir Details as shown on sheet No 6
Rock as shown on west side of spillway - very hard, impervious blue hard pan on east side.
Concrete steps 3½" Riser 4' slop Subject to slight variation because of seams and layers of good foundation rock
Concrete fill placed after dam is completed
Creek Bed
Rock Fill
Hard Blue Rock
Conc Retaining Wall

PROFILE OF SPILLWAY CHANNEL

REVISED DETAILS
FOR THE CONSTRUCTION OF
DAM & RESERVOIR No 2
FREDONIA N.Y.
FRETTS, TALLAMY & SENIOR
CONSULTING ENGINEERS
WILLIAMSVILLE N.Y.
NOVEMBER 1937

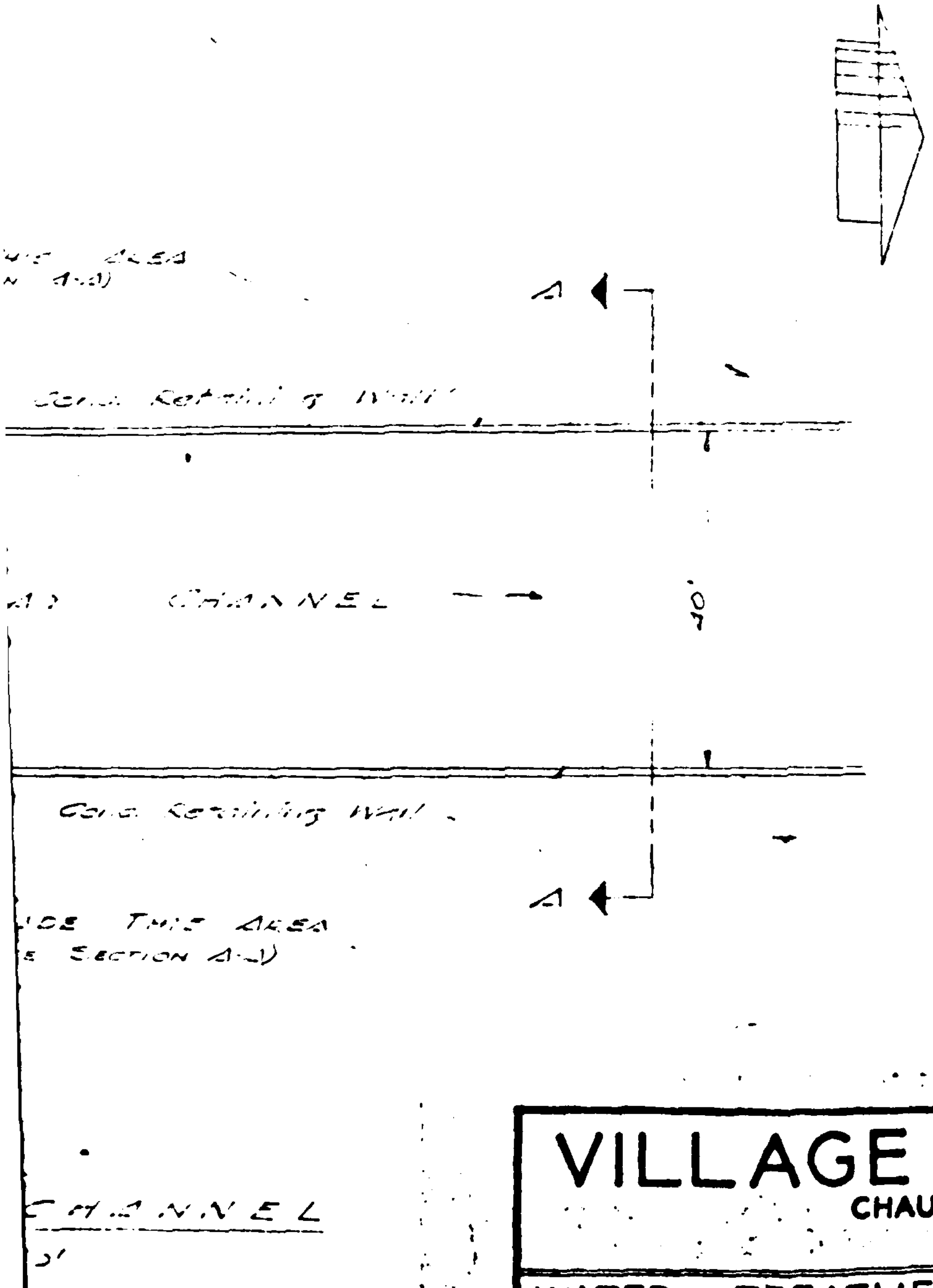
1 3


Edge Of Reservoir
REGRADE THIS AREA
(SEE SECTION A-A)
Conc. Ret
Spillway
75'
SPILLWAY
Crest Elev.
563.0
Conc. Re
REGRADE THIS
(SEE SECTION
Edge Of Reservoir
DAM
Exist. Slope

PLAN

SPILLWAY CHAN

Scale: 1"=20'



…HIS AREA
…N A-A)
A
Conc. Retaining Wall
…A) CHANNEL
10'
Conc. Retaining Wall
A
…IDE THIS AREA
…E SECTION A-A)
CHANNEL
…5'

VILLAGE OF FREDONIA

CHAUTAUQUA CO., N.Y.

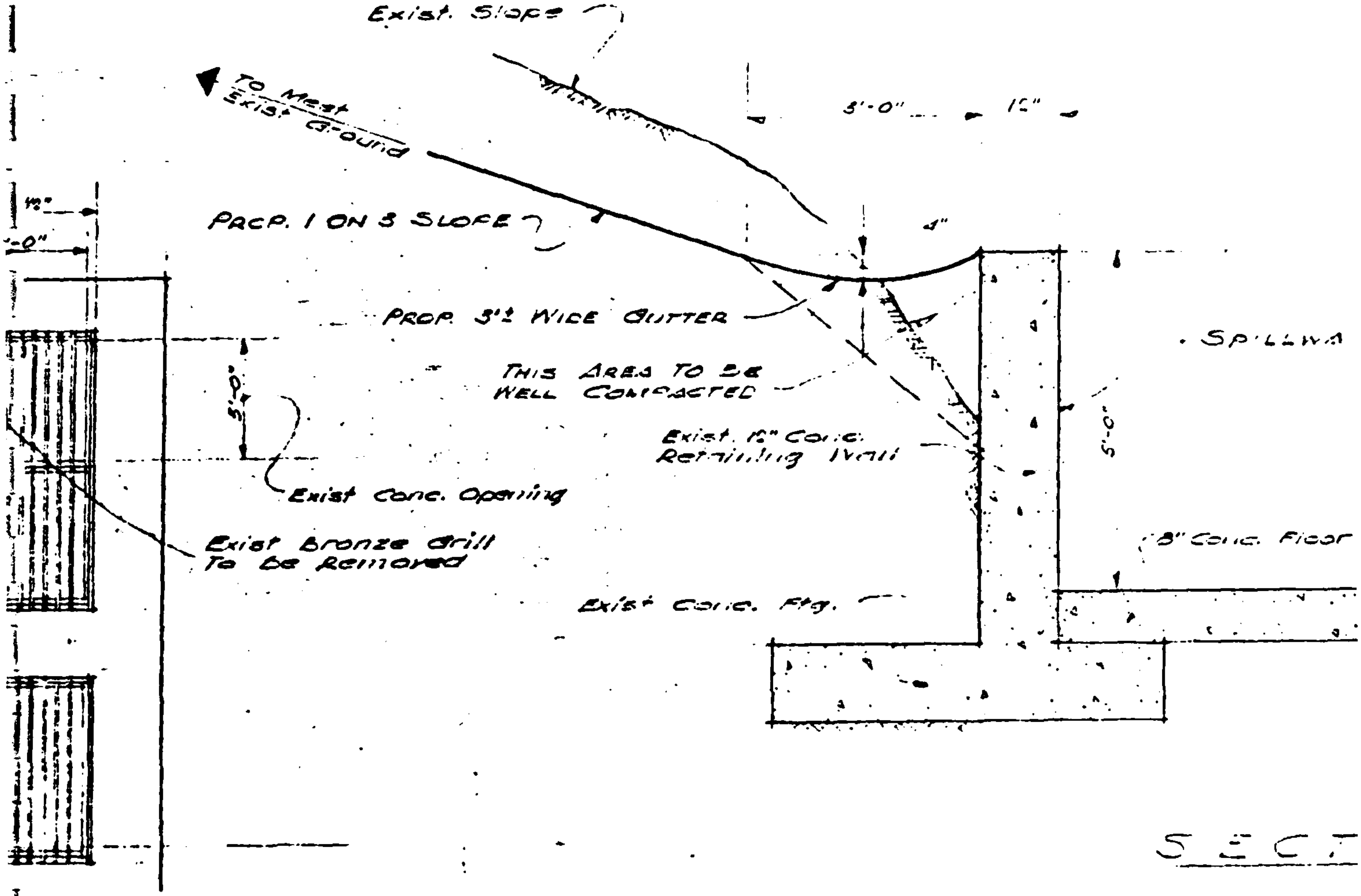
WATER TREATMENT PLANT EXPANSION

RE-GRADING PLAN FOR EXIST. SPILLWAY
REVISIONS TO EXISTING INTAKE

PREPARED BY
BISSELL, BRONKIE & ASSOCIATES ENGINEERS
WILLIAMSVILLE 21, N Y.

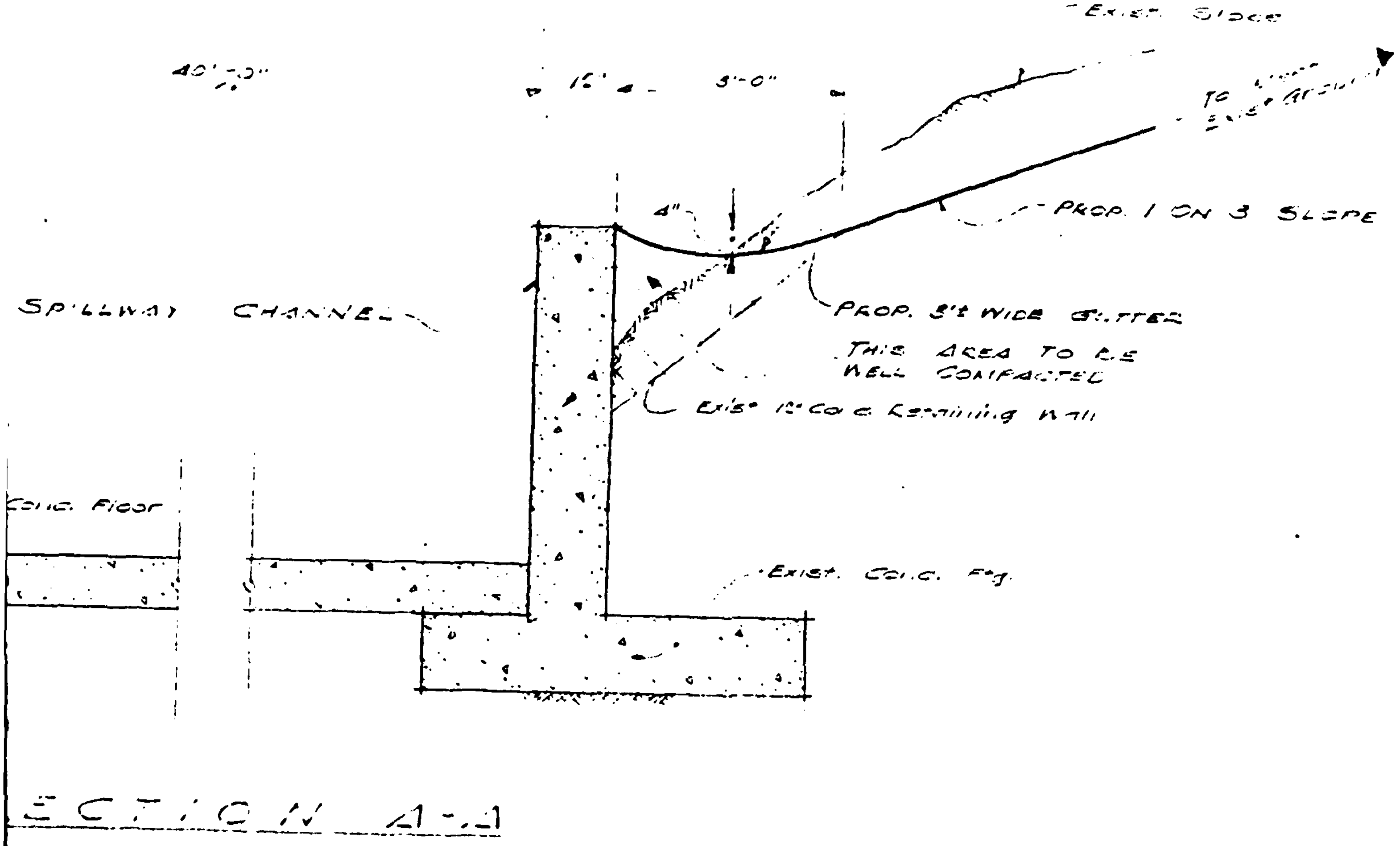
2

REVISED	BY	DATE	NOV 1965	TOWN JOB Nº	
		DESIGNED BY	W. H. M.	S.B&B JOB Nº	20625
		TRACED BY	G. R. P.	SHEET Nº	20 OF 24
		FIELD BOOK	NONE	DRAWING Nº	
		FIELD BOOK			


Exist. Slope
To Meet Exist. Ground
3'-0"
12"
12"
-0"
Prop. 1 on 3 Slope
4"
Prop. 3'± Wide Gutter
This Area To Be Well Compacted
5'-0"
Exist Conc. Opening
Exist. 12" Conc. Retaining Wall
Exist Bronze Grill To be Removed
Exist Conc. Ftg.
Spillwa
5'-0"
8" Conc. Floor

SECT

1


Exist. Slope
40'-0"
12"
3'-0"
To Exist. Ground
4"
Prop. 1 on 3 Slope
Spillway Channel
Prop. 3'± Wide Gutter
This Area to be Well Compacted
Exist. 12" Conc. Retaining Wall
Conc. Floor
Exist. Conc. Ftg.
ECTION A-A

2

VILLAGE OF FREDONIA

CHAUTAUQUA CO., N.Y.

WATER TREATMENT PLANT EXPANSION

RE-GRADING PLAN FOR EXIST. SPILLWAY
REVISIONS TO EXISTING INTAKE

PREPARED BY
BISSELL, BRONKIE & ASSOCIATES ENGINEERS
WILLIAMSVILLE 21, N.Y.

REVISED	BY	DATE	NOV. 1965	TOWN JOB No	
		DESIGNED BY	W. H. M.	S.B&B JOB No	20625
		TRACED BY	G. R. P.	SHEET No	20 OF 24
		FIELD BOOK	NONE	DRAWING No	

END

DATE
FILMED

11-80

DTIC